# HOME POWER

THE HANDS-ON JOURNAL OF HOME-MADE POWER

Issue #58 April / May 1997

## Features





## GoPower





## Fundamentals



## Things that Work!

Cover: Pat Preston's system in Colorado gets a retrofit from Mick Sagrillo and the SEI Crew. Story on page 6.

## Homebrew



## Columns



## Regulars



## Access and Info

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Winter time on Agate Flat. Building comes and goes in waves along with the weather. When the road dries out enough for my access from town and Ben has a break from magazine mechanics, the bath house project moves steadily forward. The roof is on and glass is in. Unstuccoed bale walls are settling out and staying dry under ample overhangs. Field stones have been hauled from across the creek and laid to form our southeastern retaining wall.The composting toilet and adjoining walkway from the house are a day or two away from being useable.

Richard, Karen, and Ben have been fielding a stream of calls and letters about the project. Some folks are requesting plans and others are simply expressing curiosity. The nature of the building doesn't lend itself to what one might call a plan. Our design and planning has been, and continues to be, a pretty dynamic process. Morning coffee turns into envelope sketches and afternoon construction. Details are gleaned and recycled from books and past projects. Dimensions are based largely on the salvaged materials that show up. We are hoping that future HP articles will illustrate building techniques that can be applied universally to individual building sites and available materials. Thanks for your response and take it easy,

–Joe Schwartz for the soon to be squeaky clean HP Crew.

## People

Bill Barmettler

Perri Bocci

Logan Brown

Mike Brown

Sam Coleman

Kathleen Jarschke-Schultze

Stan Krute

Don Loweburg

Karen Perez

Richard Perez

Shari Prange

Benjamin Root

Mick Sagrillo

Dennis Scanlin

Bob-O Schultze

Joe Schwartz

Michael Welch

John Wiles

Myna Wilson

## *" Think about it…"*

***"Since I do not forsee that atomic energy is to be a great boon for a long time, I have to say that for the present it is a menace."***

***Albert Einstein***

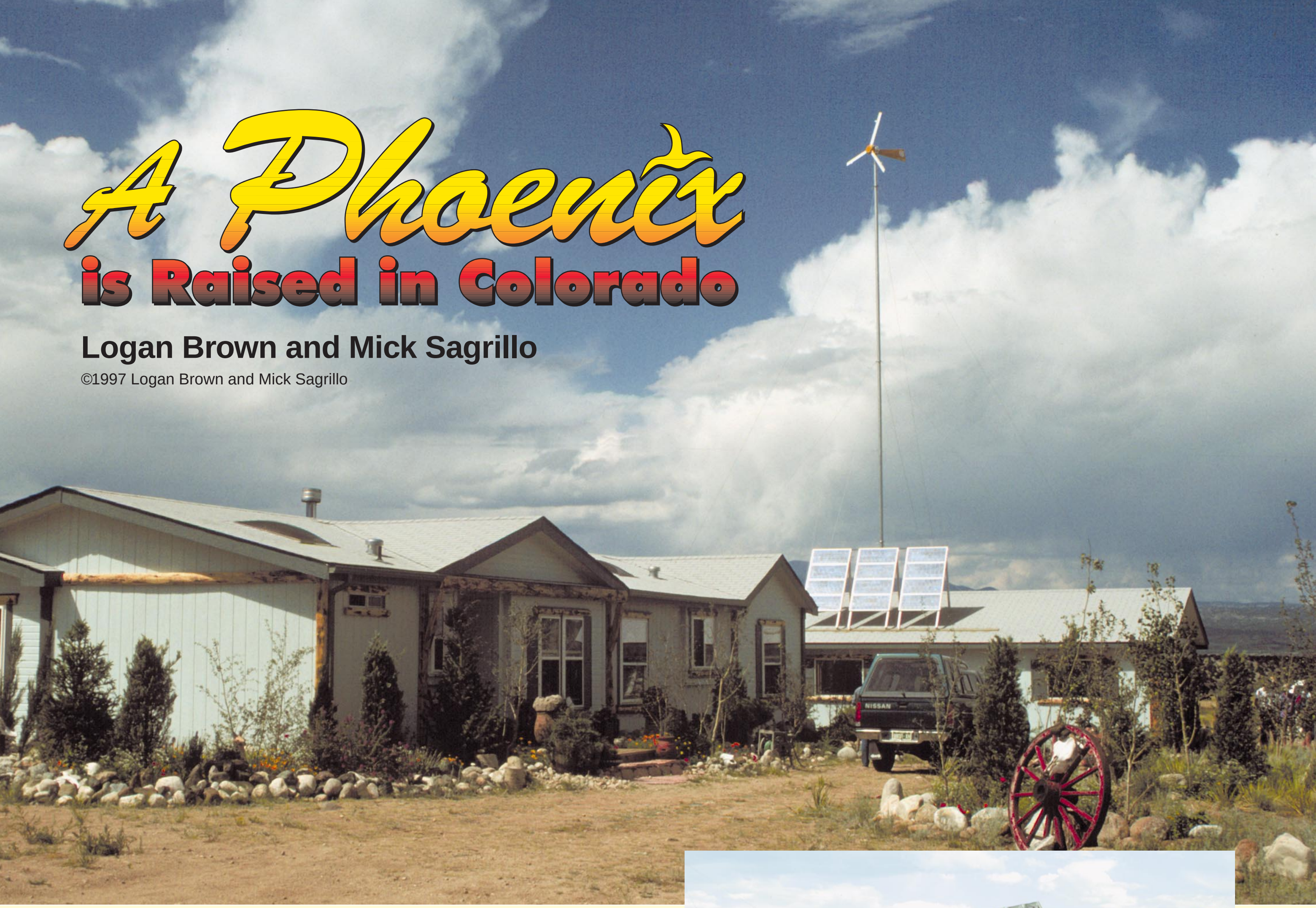
SUNELCO

full page

four color

on negatives

this is page 5



# A Phoenix is Raised in Colorado

**Logan Brown and Mick Sagrillo**



Pat Preston's wind generator fell from its tower and crashed onto the roof of her garage. This occurred less than one year from when she had the wind/PV hybrid system installed at her Colorado home. Bolstered by a steadfast faith in renewable energy, and with technical assistance from Lake Michigan Wind & Sun and a passel of students from Solar Energy International, Pat has her wind/PV system flying again.

Left: The hard-worked crew, including Mick Sagrillo (left-front) and Pat Preston (third from right).

**Why Renewable Energy?**

Pat's home is situated on a semi-arid plateau between Buena Vista and Salida, in central Colorado. There are few trees and a prevailing westerly wind that blows year-round, but hardest in the winter. The location provides an ideal solar site with an abundant wind resource. When asked why she chose renewable energy, Pat gives a quick answer, "Non-dependence on the grid." Self-reliance coupled with an unwillingness to pay $12,500 plus for access to grid power enticed her to go solar. She intuitively valued a hybrid system because, "the wind and sun compliment each other so well." A first-time independent energy producer, Pat initially felt leery about RE system maintenance and operation. "I'm computer and technology illiterate. But after living with the system for a short time, I became comfortable with it."

**Setback!**

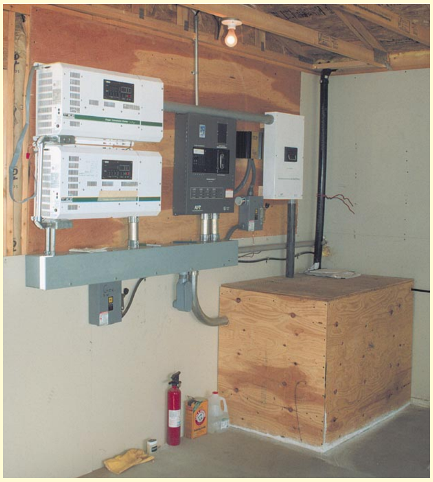
Unlike most owner/operators who often experience a few minor problems in their first year, Pat's problems were not small or easily remedied. The wind turbine, a Bergey 850, was improperly installed by a local dealer. It fell from its tower and destroyed part of her garage, as well as itself, only months after installation. In a letter from Pat, she shared her thoughts on this accident. Pat wrote, "Running into a few snags, like my cherished Bergey blowing off its tower, did in fact diminish my spirits. However, the sense of freedom in experiencing power from the wind and sun was still strong, even after the disaster." Pat later said that she "had no reservations at all" about repairing her Bergey and having it re-installed.

Above: Pat enjoying some of her home-made electricity.

**The PV Electric System**

Pat's PV system consists of a dozen 51 Watt Kyocera panels wired in series-parallel to deliver 18 Amps maximum at 24 VDC nominal. The modules are rack-mounted on her garage roof, and permanently fixed at a 45° tilt. A 30 foot round trip of #8 stranded copper wire brings the array power into an Ananda APT-3 Powercenter. There is a weather-proof disconnect switch mounted on the module mounting rack. This allows a person to disconnect the PV's from the system when service is required on the array.

The module frames are grounded by a #6 bare copper wire attached to an eight foot copper ground rod driven below the garage roof drip line. This location insures adequate soil moisture in desert country.



Left: The control room in the garage. Note the "safety equipment" on the floor.

**The Wind System**

The second half of Pat's RE system is a Bergey 850 wind generator. The turbine is now mounted atop a 64 foot tubular guyed tilt-up tower. The tower is made of 4 inch Schedule 5 galvanized steel pipe, guyed every 20 feet. It is located approximately 30 feet from the garage. The Bergey 850 has a rated output of 850 watts at a wind speed of 28 MPH. This translates to 35 Amps maximum at 24 VDC nominal. Nearly 190 feet (round trip) of #4 stranded aluminum cable delivers power through a three phase 30 amp safety disconnect switch protected by a lightning arrestor. From there power travels through the standard Bergey regulator and into the batteries. Note the disparity between the 35 Amps DC charging current of the Bergey and the 30 amp safety disconnect. This is because the Bergey produces three phase ac current, with each wire seeing only two thirds of the maximum DC charging current. The safety disconnect is on the ac side of the controller, not the DC side.

**"Phoenix" Flies Again**

Pat's wind generator was originally mounted on ten feet of four inch water pipe. The pipe passed through the garage roof and was bolted to the gable end wall. As a result of this improper installation, the Bergey vibrated violently and soon fell, causing considerable damage to both her garage and the wind generator. That these were the only things damaged by the fall was a blessing (see side bar). Now properly installed, Pat says the wind generator is "operating quietly and working wonderfully."

Above: Students learn how to use a transit from Johnny Weiss.

Part of the students' responsibility in this workshop was to leave Pat with a working wind system. Johnny and Mick worked with Pat for months beforehand so that all was choreographed and the installation would go smoothly. Together with Pat, they laid out the anchor location for the tower. Pat then hired a backhoe to dig the holes for concrete. Pat's soil is quite sandy and rocky, and standard screw-in anchors were inappropriate for the site.

The students wheelbarrowed concrete from a truck and trued the anchors before the cement set. Later in the week, they assembled the tower, raised it, and leveled it with the aid of a transit. The tower was lowered so that the Bergey 850 and wires could be installed. The wiring was buried in PVC conduit, brought into the garage, connected to the Bergey controller, and then to the batteries.

Eight foot ground rods were driven at five locations around the tower, at each of the four anchors plus the tower's base. After a final check, the tower was again raised and the 850 began pumping electricity into Pat's battery bank.

**Batteries**

The batteries, along with all power conditioning equipment, are located in the garage. Pat's RE electricity is stored in 16 six Volt, 350 Amp-hour Deka lead-acid batteries. The bank is wired to provide 1400 Amp hours of storage at 24 VDC. They are located beneath the APT-3 in an insulated wooden battery box that is vented to the outside. The 2/0 battery interconnects were neatly installed by the original dealer. For safety, Pat wisely keeps a large box of baking soda, rubber gloves, safety glasses, and a fire extinguisher nearby. Servicing the batteries is a bit difficult because of the size of the battery box. The batteries are fitted tightly into the wooden enclosure. This looks neat, but leaves little room to access individual cells for routine maintenance or removal.

Above: Pouring concrete for the footings.

**Inverters**

Two Trace SW4024 inverters are wired together to provide both 120 and 240 vac. Each Trace is individually connected to the battery bank and has its own disconnect. The second was installed so the existing 240 vac water pump could be operated. Pat could have done without the second inverter if she had replaced her pump with a 120 vac unit, but she appreciates the security and greater capacity that two inverters provide.

The inverters, Powercenter, and all safety disconnects had their chassis interconnected with a #6 bare copper wire. This wire and the ground wire from the lightning arrestor were connected to an eight foot ground rod driven below the garage roof drip line.

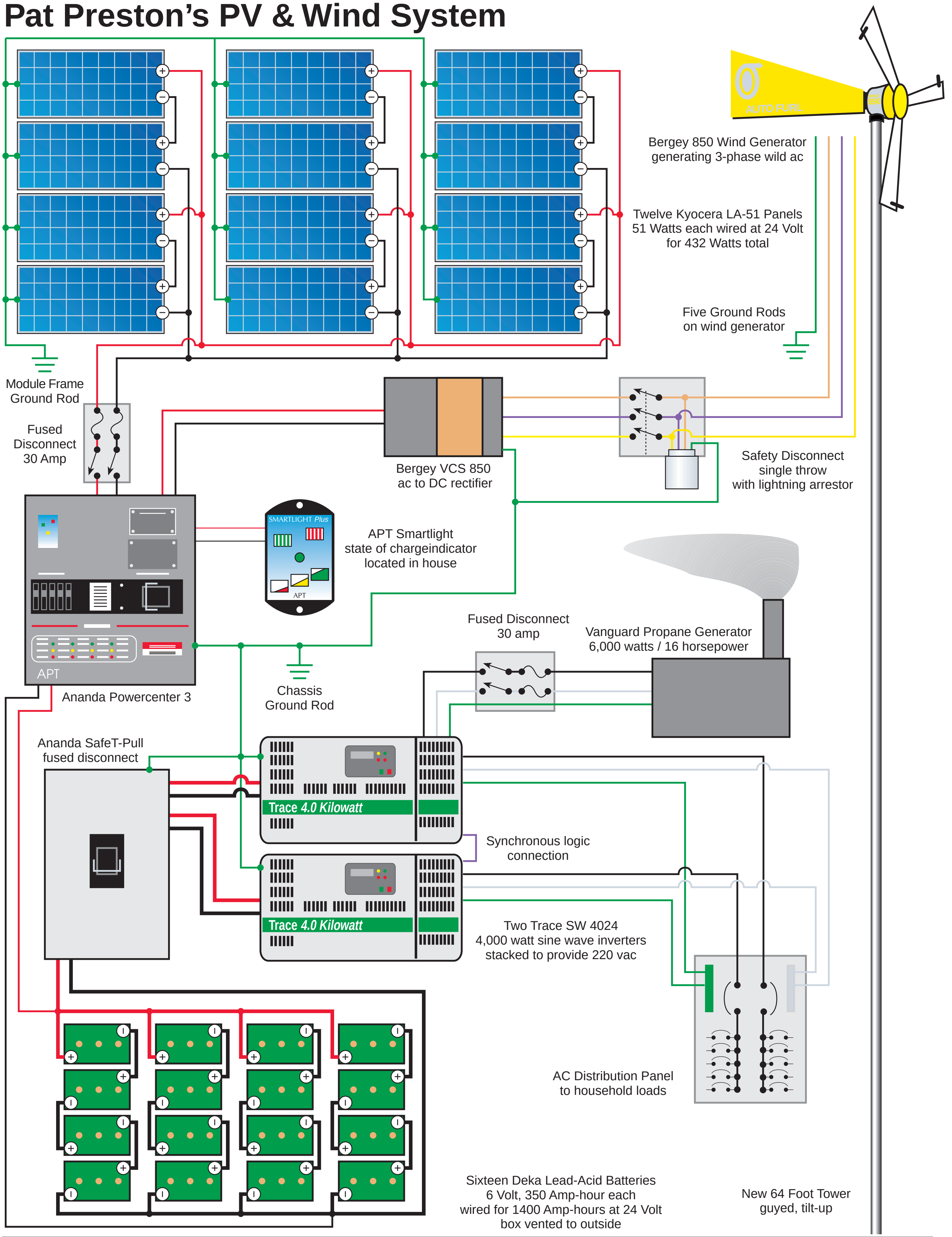
**Tune-up**

The students, under the expert guidance of SEI's Johnny Weiss, proceeded to examine and fine tune the battery, inverter, and control subsystems. For example, the specific gravity of all of the battery cells was checked and recorded, and all terminals cleaned and tightened. Controller set points were adjusted and all wire connections checked. Finally, the Trace inverters were reprogrammed.

Pat's only problem with the inverters was the result of poor education and communication, so she eagerly participated in the tune-up. Originally, some of Pat's smaller loads, particularly the compact

Below: Going over final measurements before the "mud" sets up.

# Pat Preston's PV & Wind System



Above: Preparing the Bergey for raising...

Right: ...and up she goes!

fluorescents, would not start when individually turned on. When we examined the "search watts" setting on the Trace, we found that it was set too high for her smaller loads to trigger the inverter start-up. The inverter would remain "asleep" unless a larger load was turned on. This was remedied by bypassing the "search watts" option, leaving the inverters on all the time. Having the inverters constantly "awake" causes a negligible daily load increase.

**Genset**

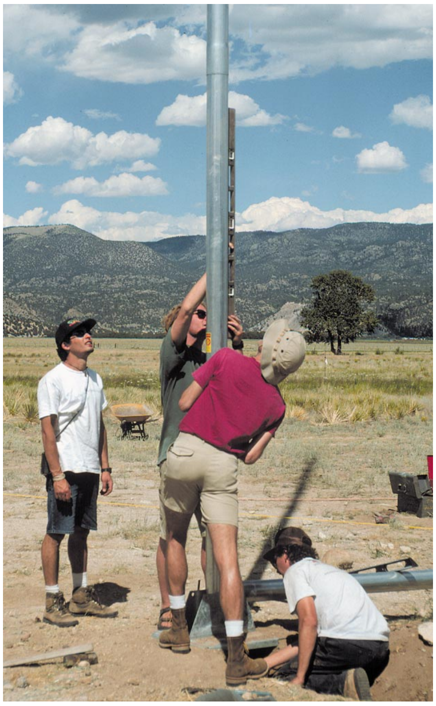
Stored in a shed built onto the outside of the garage, Pat keeps a Vanguard 16 kw Briggs and Stratton propane generator. While the Bergey was out of service, the generator was used frequently to help charge her battery bank through the built-in 120 Amp battery charger in the Trace. Now that the wind generator is up and spinning again, the generator has never run to charge the batteries. However, it is started occasionally for maintenance purposes. Inside the garage with the rest of the system controls, there is a separate 120 vac 30 amp safety disconnect switch for the genset.

**Power Controls**

The PV charge controller is inside the Powercenter 3. Its charge termination point is set at 29.3 V. The Bergey 850 has its own charge control unit, a Voltage Control System (VCS) 850. The VCS 850 charge termination point is set at 27.6 V. Under this set up, the Bergey, along with the PV's, supplies bulk power to the batteries while the PV's are responsible for the float or trickle charge.

Unlike other wind generators, the Bergey 850 does not need a diversion load when there is excess charging power. Instead, the VCS 850 disconnects the Bergey from the batteries, similar to a PV controller. The flexible pitch blades and auto-furling tail mechanism on the Bergey are designed to allow it to safely operate under such no-load conditions.

Right: Making sure the tower is plumb.



Below: Tensioning the guy cables.

Leftt: Installing ground rods. Author Logan Brown stands at far right.

**Pat Preston's RE System Cost**

| *Wind system components* | Cost | % |
|---|---|---|
| Bergey 850 | $2,195 | 9.2% |
| 64 foot tilt-up tower | $1,210 | 5.1% |
| Labor (SEI administrative fee) | $750 | 3.2% |
| Backhoe to excavate holes | $370 | 1.6% |
| Concrete for footings | $300 | 1.3% |
| 190 feet #4 aluminum "tri-plex" | $115 | 0.5% |
| Freight for the tower | $100 | 0.4% |
| Conduit and misc. connectors | $77 | 0.3% |
| 3-phase safety disconnect | $50 | 0.2% |
| 3-phase lightning arrestor | $50 | 0.2% |
| Kellums "tri-plex" supports | $43 | 0.2% |
| *Total wind system installed cost* | $5,260 | 22.1% |
| *PV system components* | Cost | % |
| 12 LA-51 Kyocera PV panels | $4,548 | 19.1% |
| Roof mounts | $237 | 1.0% |
| Safety disconnect for array | $50 | 0.2% |
| Wire for run and interconnects | $38 | 0.2% |
| Surge arrestor | $10 | 0.0% |
| *Total for PV "generator"* | $4,883 | 20.6% |
| *Balance of system components* | Cost | % |
| 2 Trace SW4024 Inverters | $5,960 | 25.1% |
| 16 Deka 350 Ahr 6V batteries | $2,800 | 11.8% |
| 16 hp 9 kw Vanguard gen-set | $2,200 | 9.3% |
| Ananda Powercenter 3 | $995 | 4.2% |
| Miscellaneous parts | $898 | 3.8% |
| SafeT-Pull disconnect | $255 | 1.1% |
| Original Bergey "tower" | $250 | 1.1% |
| Battery interconnects | $162 | 0.7% |
| Safety disconnect for gen-set | $50 | 0.2% |
| Smartlight Plus | $39 | 0.2% |
| *Total for B.O.S.* | $13,609 | 57.3% |
| *Grand total* | $23,752 | |

Note: Labor costs for PV and BOS installation unknown.

## Lessons Learned

The original Bergey "tower"

When Pat originally contacted the local RE dealer about installing a wind/PV hybrid system, he told her that he would be willing to install the wind system, but it would be his way. Because this dealer had no experience with towers or wind generators, that meant installing the Bergey 850 on a piece of water pipe attached to Pat's garage wall. The photo shows the original Bergey installation.

Pat had seen other wind installations, and knew that wind generators were always mounted on towers. However, against her better judgement, she deferred to the dealer's decision in mounting the generator. In hindsight, Pat now believes she should have contacted another more experienced dealer.

Trouble began almost immediately when the wind generator began spinning. The Bergey set up a resonant frequency (as does any rotating electrical generating device) whose sound was amplified by the hollow structure of the garage. This is not unlike the amplification of sound in a guitar when you pluck a string. The sound was so loud that Pat could hear it constantly in the house with all doors and windows closed.

Next, she noticed that some of the ceiling braces in the garage were loose. A carpenter was contracted to re-nail the braces and add extra cross braces so that the garage would not disassemble itself. The SEI students found that the plywood upon which the Trace inverters, Ananda Powercenter, and electrical wiring were mounted was barely attached to the garage walls. The vibration had shook the nails almost completely out of the plywood. This is lesson #1: wind generators are mounted on towers, not on buildings.

Additionally, the original dealer decided to mount the Bergey 850 on a ten foot piece of water pipe, rather than secure the proper tower tubing as specified by the factory. The wind generator's mounting bolts were too short for the thick water pipe, but were used by the dealer anyway. Within a few months, the mounting bolts vibrated out of the water pipe, and the Bergey fell from its perch. In the

process of tearing up the garage roof, the Bergey sustained considerable damage, including three broken blades. Lesson #2: install wind systems only on factory approved mountings.

When contacted about all of this, the original dealer contested everything, including the expertise of the manufacturer, Bergey Windpower Company. It looked like Pat would get stuck holding the bag for the damages incurred, just over $1000 plus shipping. As it turned out, the original dealer's distributor agreed to pay the damages, but only after some careful negotiations. Hopefully the original dealer has been cut off by the distributor. If so, it would be for a just cause. While Pat got her Bergey repairs paid for, she did have to shell out a comparable amount to repair the garage. Lesson #3: the obligation of a dealer is to respect your customers and stand behind your installations. Problems can occur with even the best of installers. When mistakes happen dealers should own up to them, learn from them, make good on them, and move on, all the wiser for the experience.

And finally, lesson #4: homeowners should not be afraid to question a dealer about what he or she is doing. Notice I said "question" and not "challenge." If you don't feel comfortable with the level of expertise of the dealer or installer, look elsewhere for a qualified person to do your work. However, take time to explain to the first dealer the reasoning behind your decision. You may even want to recommend SEI as a place for a novice dealer to get some practical hands-on experience.

—Mick Sagrillo

### Metering

The metering in Pat's system consists of the battery voltage meter available on the Trace inverter control panel and an APT Smartlight installed in her house. While the Smartlight quickly lets her know basic information about her battery bank's voltage, Pat's personal interest in her RE system has left her wanting a more detailed and informative remote meter. Pat's abundant wind resources allow her to equalize her battery bank quite often, and she would like to be able to monitor her battery voltage without having to go to the garage. A Bogart TriMetric or a Cruising Equipment E-Meter, for example, would fit this system's needs well.

### Moving on…

Pat's property is now for sale. She reports having encountered some hesitation from potential buyers, but no outright refusals as a result of the renewable energy system. "Having this much charging capacity is like being on the grid," she said. When asked if she would install a renewable energy system on her next home, Pat replied, "I'll definitely do it again. I'm planning on doing some traveling, though. Can you help me put PV's on an RV?"

### Thank You

Besides being an eager student, Pat is an enthusiastic RE owner who unquestioningly allowed the SEI students to poke and prod at her wind and PV systems. Lake Michigan Wind & Sun and Solar Energy International are grateful for her support and hospitality in hosting this installation workshop. Pat is a Phoenix in her own right. May her days be filled with sunny mornings and breezy afternoons.

### Access

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E-Mail: LMWandS@ITOL.com

## A Testimonial by Logan Brown

Interested in learning about solar and wind power?

As a college student interested in energy conservation and alternative sources of energy, I certainly was. While working for the National Wildlife Federation after graduation, I discovered Solar Energy International (SEI). SEI is a non-profit organization whose mission is to provide education and technical assistance to encourage the use of renewable energy.

After enrolling in their entire Renewable Energy Education Program (REEP), I moved to SEI's headquarters in Carbondale, Colorado. I participated in workshops on photovoltaics, micro-hydro, wind power, and solar home design. I had no prior training in renewable energy before I came to SEI. However, the hands-on nature of the workshops helped me learn quickly.

Our wind workshop was instructed by Mick Sagrillo of Lake Michigan Wind & Sun. Under the direction of Mick and Johnny Weiss, Director of SEI's REEP program, sixteen participants spent one week in SEI's classroom/lab learning the basics of wind technology. The second week of class was spent installing two wind generators at private residences in Colorado. Our first installation was a Whisper 1500 that we put on a tilt-up tower. The second installation, at Pat Preston's home, is described in the accompanying article.

SEI's next Wind Power Workshop is July 21-August 1, please contact: SEI, PO Box 715, Carbondale, CO 81623; phone 970-963-8855, fax 970-963-8866, or E-Mail sei@solarenergy.org.

# Hup® Solar-One™ Batteries

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|---|---|
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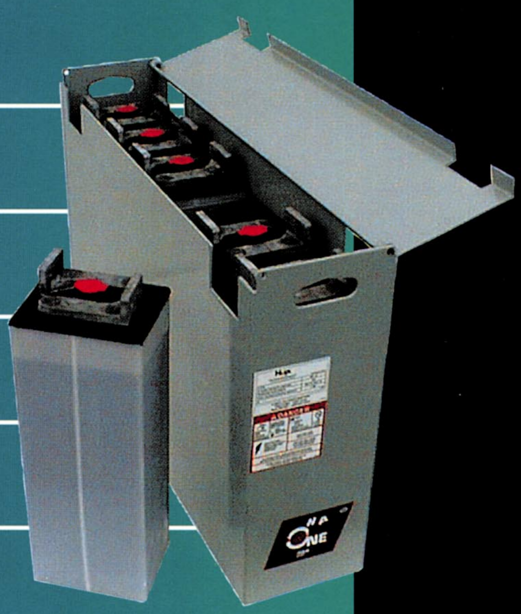
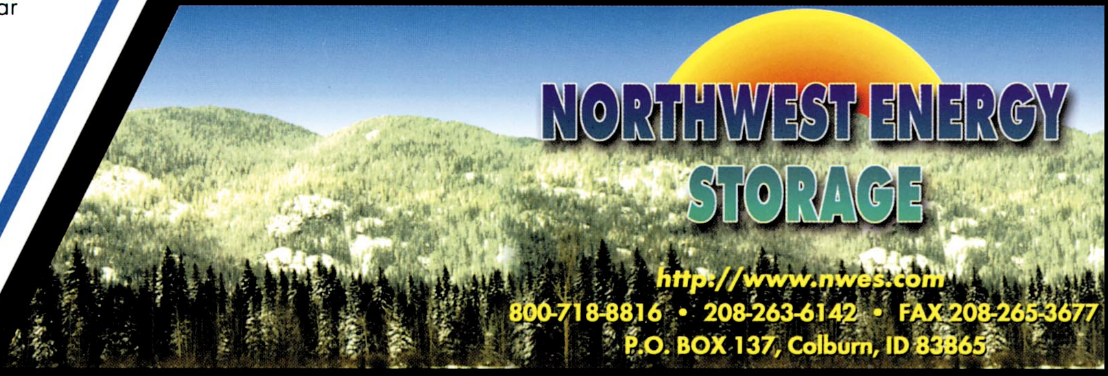
| Lead-plated copper intercell connectors with stainless steel connecting hardware | Quality connectors maximize energy transfer, reduce corrosion during the Solar-One's long service life |
| Free shipping in continental United States | Lower costs |
| ISO-9000 Certified plants and processes | Assures you of batteries made to high international quality standards |



*Ask your **Hup** Solar-One Representative for a copy of our exclusive 10-Year Warranty.



# Empirical Investigations of Solar Water Heating Technology

Dennis Scanlin



Over the last 15 years students and faculty at Appalachian State University have been experimenting with solar water heating technologies. We designed, constructed and tested quite a few "batch" or integral collector storage (ICS) systems and developed low cost designs that perform very well. Recently we began to empirically investigate active solar water heating systems with freeze protection.

We constructed three wedge shaped test platforms and collected enough components to put together every major type of solar water heating system. Most of the systems are designed and constructed by students taking the Solar Energy Technology course offered by the Department of Technology at Appalachian. Students have designed and built solar ovens, food and lumber dryers, space heating systems, water distillers, and greenhouses. Recently we've spent a good bit of time on PV and solar water heating technology.

For the solar water heating activity, the class splits up into three groups with approximately five students in each group. Each group designs, builds, and tests a solar water heating system. Because we have three systems being built simultaneously, we try to identify hypotheses to test and then synchronize our efforts to maintain as much validity as possible. We have compared direct (drain down) to indirect (drain back and propylene glycol), two pump indirect glycol system to a one pump indirect glycol, single wall exchanger to double wall exchanger, DC to ac, and slow to fast flow rates. This article summarizes our findings.

**Methodology**

Each of the modules has identical 15 gallon storage tanks and 12 square foot collectors. The average person uses 10 to 20 gallons of hot water per day, so our small tanks would only satisfy the needs of one average person. Except for the size of the tank and collector and the length of the piping connecting them, all other components are the same as in a full size system. The collector is adequate for the storage tank capacity. In general, one square foot of collector will heat 3/4 to 2 gallons of water, depending on locale. Ours have one square foot of collector for every 1.25 gallons of water.

Using the three modules we are able to test two hypotheses at the same time. The systems are constructed by the students in our lab and then wheeled outside for testing. All 3 systems are tested side by side at the same time. The storage tanks are filled with water from garden hoses connected to an exterior hose bib. The hoses are left connected and the water storage tanks are kept pressurized throughout the testing.

**Data Collecting Equipment and Procedures**

We collect temperature data with an assortment of digital and analog thermometers and a four channel data logger. The analog thermometers can be slid into a well and then screwed into female pipe threads, like at the top of the storage tank. The best prices I have been able to find on these analog thermometers ($12.70) and many other solar water heating components are from American Energy Technologies, Inc. (AET). We purchased many solar water heating components from them with good service. They have a nice catalogue and engineers on staff to answer questions. The three digital thermometers we use are Quadra-Temps from Heliotrope General. A four sensor thermometer costs $202.87. The data logger is the XR220 Pocket Logger from Pace Scientific, costing about $500. It is a four channel recorder capable of measuring temperature, humidity, pressure, and ac current. It operates on a 9 Volt battery and the data can be transferred to any MS-DOS compatible PC running Pocket Logger software. The data can be easily charted and/or imported into spreadsheet and statistical software packages. For flow measurements we use both Taco and Blue White flow meters. The Taco meters are no longer available. The Blue White meters cost about $50. We use the three Quadra-Temps, analog thermometers, and flow meters to manually collect temperatures as often as possible during the day. The Quadra-Temp sensors are attached to the copper piping with hose clamps or tape. Normally we are interested in the four connections to the heat exchanger, if one is being used. The data is collected every hour or whenever convenient and is recorded on paper. The data can be transferred to computer for analysis and charting. Recently we began using the four channel Pocket Logger for data collection. Its sensors can be taped to the piping and it can automatically collect data as often as desired. This data can be easily charted and/or statistically manipulated.

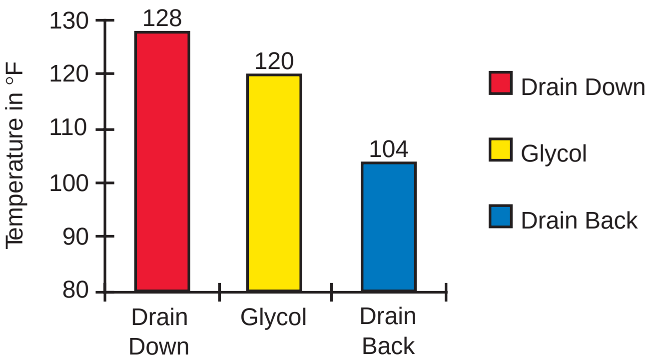
We also measure the average tank temperature at the end of the day by shutting off the water supply to the storage tank, opening a drain valve at the bottom of the tank and a valve at the top of the tank (to let air in), and holding an analog thermometer in the stream of water as it exits the tank. Every 30 seconds we record the temperature until the tank empties. The temperatures are then averaged. It is not a perfect system, but it works well enough. There is no electric backup connected to the systems we have tested and also no water is drawn from the tanks during the test period.

Above: Installing an AET single wall heat exchanger.

**Direct vs. Indirect**

The direct system circulates potable water through the solar collector. It consistently performs the best in our tests. Chart 1 shows the average tank temperatures for all test days for three of the major types of active solar water heating systems in use in the US today. It compares a direct system, an indirect glycol system with a natural convection potable water loop and a single wall heat exchanger, and an indirect drain-back system with a home made drain back tank. For freeze protection in the direct system we have been using drain-down valves manufactured by Heliotrope General (Figure 1). They manufacture both an ac controlled valve (HG-Spool) and a new DC PV controlled valve (Solar-Sidebar). We have used them both. The valve opens in the morning with sufficient solar insolation and a small ($\leq$ 1/40th HP) stainless steel or bronze pump is turned on at the same time and pumps pressurized potable water into the collector. When the insolation decreases sufficiently the valve closes and prevents

**Chart 1: Direct vs. Indirect average daily tank temperature in °F**




any additional flow into the collector. At the same time the pump turns off and the valve allows the water existing in the collectors and piping to drain out. The ac valve requires a special controller (DTT-74 or DTT-794) and two 10 KΩ thermistors, which are available from Heliotrope General. The DC PV controlled Solar Sidebar uses a 10 Watt PV module. All the major components needed are included and assembled. The system only needs to be attached to the collector and storage tank. No controller is required. It is a nice unit, and is quick and easy to install. Heliotrope has recently improved the drain-down valve and offers a limited ten year warranty on this product.

The indirect systems have both a collector loop and potable water loop. The loops flow in opposite directions and the fluids in these loops never mix. The potable water loop picks up the heat from the collector loop through a heat exchanger, which is nothing more than a copper pipe or pipes inside another pipe or container. The indirect systems we have explored are the drain-back and the propylene-glycol anti-freeze.

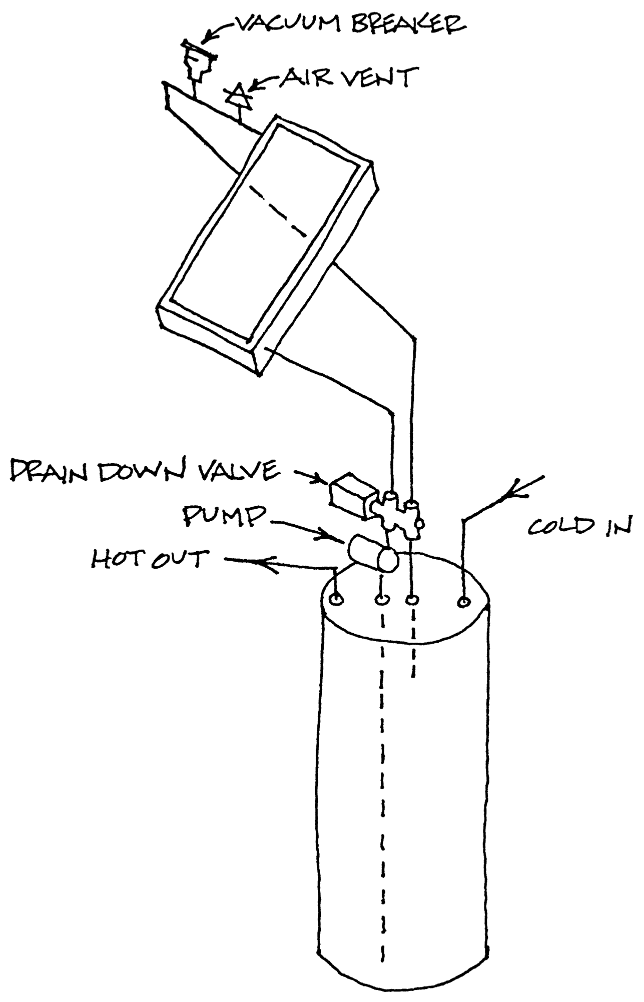
**Drain Back System**

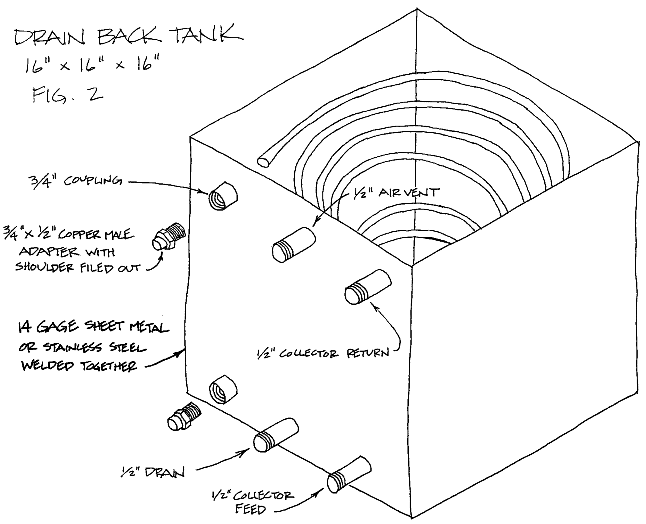
Our home built drain back tank is a 16 x 16 x 16 inch steel box with a 10 foot coil of 1/2 inch copper pipe inside (Figure 2). The potable water is pumped with a small (≤ 1/40th HP) stainless steel or bronze pump through the copper coil, picking up heat from the collector water around it. Inside the steel box and around the heat exchanger is the collector water, treated with a rust inhibiting solution of sodium-hydroxide, trisodium phosphate, morpholine, and sodium dichromate (from Hicks Water Stoves & Solar Systems), which gets pumped up to the collectors by a second larger and usually cast iron (1/12 HP) pump whenever they are hotter than the water in the bottom of the tank. The two pumps are controlled by a Heliotrope General (DTT-84) differential controller and two 10 KΩ thermistors. This type of system is very common in North Carolina, especially in larger 500 or 750 gallon versions providing space heating to the house as well as hot potable water. These systems can perform very well. However, our system did not (Chart 1). The weaker performance is probably related to the increased quantity of fluid this design has to heat and inadequate insulation of the drain-back tank.

**Glycol Systems**

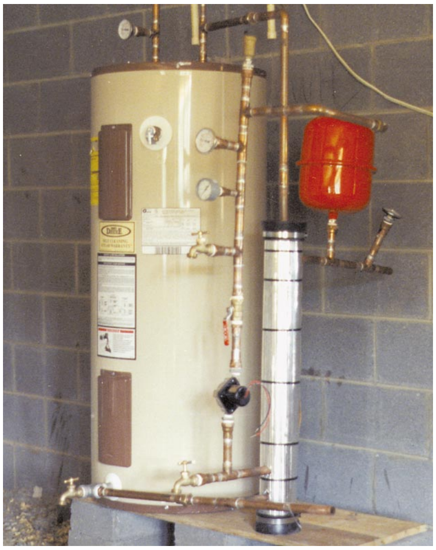
Recently we have focused our attention on indirect propylene glycol systems. These systems are simple, reliable, and inexpensive. We have been using external heat exchangers which connect directly to either an electric water heating tank (see photos) or a separate solar storage tank that would be plumbed in series with a gas fired water heating tank. These external exchangers cost a lot less than a storage tank with a built in exchanger, can eliminate the necessity of purchasing a new solar storage tank for someone who wants to add solar to an existing electric hot water heating system, and provide more flexibility in choice of storage tank size. An external heat exchanger can be

DIRECT DRAIN DOWN SYSTEM
FIG. 1






Right: A complete system minus the collector.

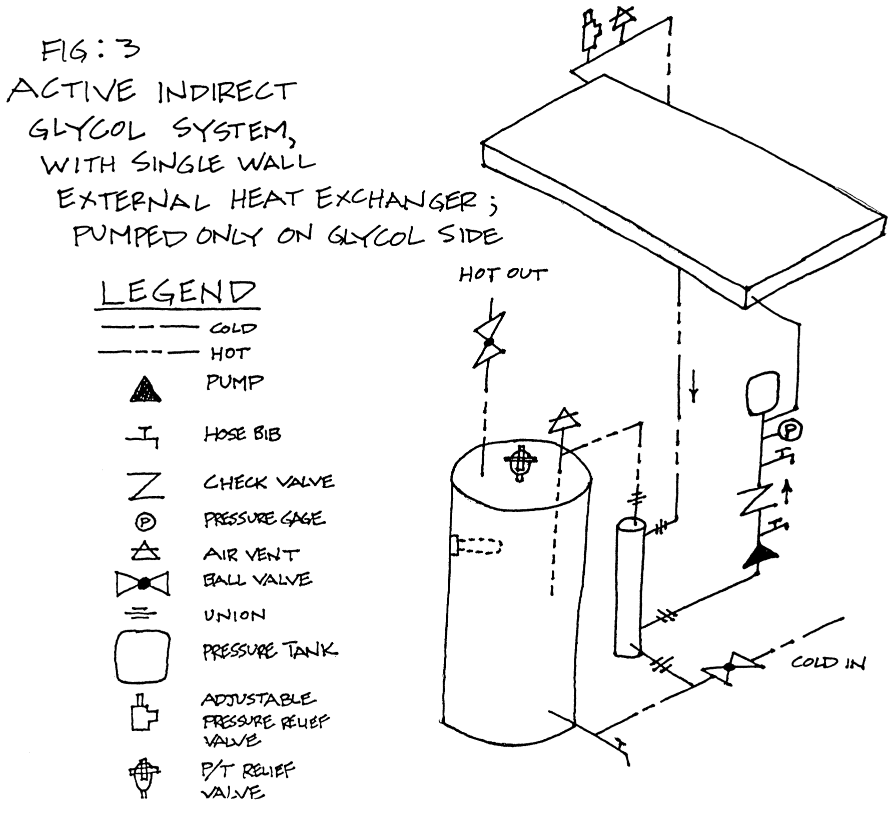


purchased for about $100 (see photo). Special solar storage tanks with built in heat exchangers can be purchased, but they are only available in a small number of sizes and are quite expensive. AET offers only one tank with a built in wrap-around heat exchanger. It is an 80 gallon tank with copper coil wrapped around the outside of the bottom half of the tank. Insulation is wrapped around the tank and exchanger. It costs $576. Shipping could add another $100 to the cost. One can purchase a regular 80 gallon electric water heating tank for about $230 at a local building supply center and other sizes are available for less. Adding an external exchanger brings the cost up to $330. So for $330 one can get essentially the same equipment as the 80 gallon tank with a wrap-around exchanger, with a delivered cost over $600.

Figure 3 shows a basic schematic for an indirect system with an external heat exchanger. The photos also show a similar indirect system, configured slightly differently than Figure 3. The system depicted has a ball valve where a check valve would normally be placed. I did not feel a check valve was needed because the collector was mounted on the ground below the elevation of the storage tank and therefore should not reverse thermosiphon at night. The system in the photo also has an extra air vent installed in the collector supply line, several analog thermometers installed, and a slightly different expansion tank position. The storage tank, exchanger, and the pipes to the tank and collectors should be well insulated. Low flow shower heads should also be installed.

A 50/50 mix of water and propylene glycol (boiler anti-freeze from Camco Manufacturing) is pumped into the system. Most full size systems hold 6 gallons or less. Some glycols come already diluted with water. Make sure you read the label. A 4 x 10 foot panel holds about 1.5 gallons. The boiler drain valves on either side of the check valve enable filling, pressurizing, and draining the system (Figure 4). We fill and pressurize to about 15 psi with a Teel drill driven pump (model 1P866). The pressure should be a little more than the pressure or static head that the fluid will exert from the elevation difference between the tank or exchanger bottom and the collector top, 1 psi for every 2.25 feet or .44 psi per foot difference. 15 psi equals 33.75 feet of static head, and is more than our modules have.

Left: Some serious problem solving going on here.



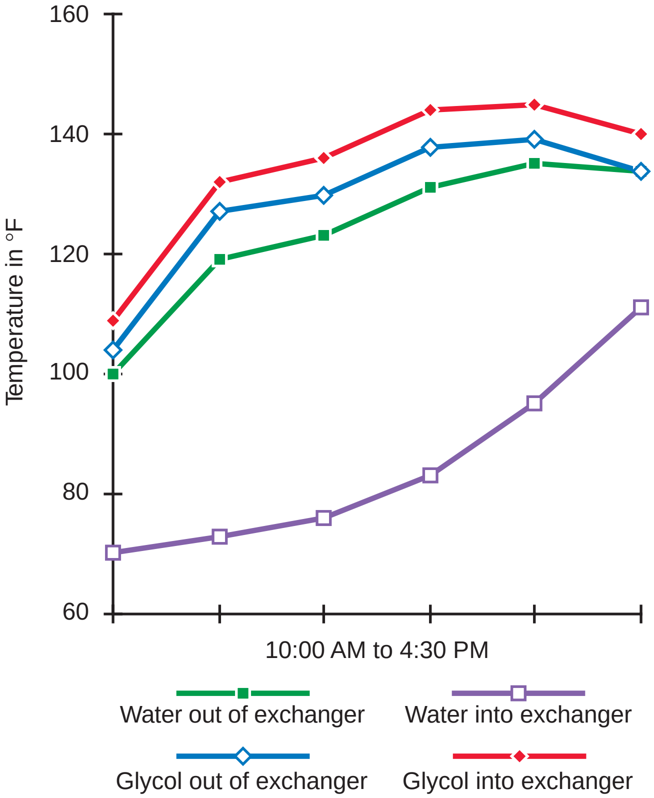

When the system is operating (Figure 3) the glycol mixture is pumped with a small (≤ 1/25th HP) cast iron, bronze, or stainless steel pump from the bottom of the exchanger through a check valve and fill/drain assembly and into the bottom of the collector. The check valve prevents reverse thermosiphoning at night or on cloudy days and needs to be pointed the correct way. An expansion (pressure) tank and pressure gauge are also depicted in this side of the collector supply loop, but could be installed anywhere in the loop. The expansion tank (normally 2 gallon) has an air filled bladder which gets compressed by the expanding hot fluid in the collector loop. This protects the system components from excessive pressure. The pressure in the expansion tank should be measured before filling the system and if needed, adjusted so that it is close to the static head pressure. They normally come precharged with 12 psi, which would be good for most situations. If a flow meter is desired it would normally be positioned vertically in this side of the supply loop. One should also install a ball valve below or above the flow meter so that the flow rate can be controlled. Some flow meters have valves built in.

The glycol fluid exits the top of the collector in the corner diagonally opposed to the supply corner in order to maintain a balanced flow through the collector. The heated glycol then passes by a 150 psi air vent installed vertically at the high point of the system and an adjustable pressure relief valve set at about 90 psi. This is a little less than the expansion tank bladder's maximum psi rating and should protect all components if for some reason the pressure would rise that high. We have had some "pop off" problems with the pressure-temperature valves commonly used on water heating tanks and like to use the adjustable pressure relief valves from AET.

Potable water is normally taken from the bottom of the tank at the drain opening. The drain is re-installed in a tee fitting at the opening. This water from the bottom of the tank can be either pumped or naturally convected through the exchanger. It flows in the opposite direction of the glycol. The hot water from the top of the exchanger is returned either at the side of the tank or in the top of the tank. This could be where the temperature/pressure relief valve is installed or in the cold in port at the top of the tank. The P/T relief valve could be removed and installed with the return water in a tee fitting or installed somewhere else in the potable loop. If the cold in port is being used for returning the solar heated water to the tank, then the cold water can be delivered to the tank in the drain port at the bottom of the tank and the cold water dip tube can be taken out and cut to reduce it's length so that water is delivered about 10 inches below the electrical element. AET recommends perforating the dip tube all up and down it's length. An air vent should be installed at the highest point of the hot water return line. This is especially important for systems that naturally convect the potable water through the exchanger. If the system has only one tank with electric elements then the bottom element should be disconnected. In this kind of system the flow rates of the potable water should be slow (less than .5 gpm) to avoid excessive mixing of the water and the temperature of the return water should be close to the thermostat setting of the element. The flow rates will be slow if the potable loop naturally convects.

Chart 2 shows temperatures from a sunny June day for each to the heat exchanger. The temperatures are for a system similar to the one depicted in Figure 3 which naturally convects the potable water through the exchanger. The average temperature of the water in the tank at the end of the day was 130˚ F.

**Chart 2: Pump Indirect Glycol external heat exchanger temperatures in °F**




We examined several configurations of indirect glycol solar water heating systems. We compared one pump systems to two pump systems. The one pump systems move the non-toxic propylene glycol fluid through the collector loop and allow natural convection to circulate the potable fluid through the exchanger. The two pump systems have pumps on the potable as well as the collector loop. We compared single wall exchangers to double wall exchangers, slow flow rates to fast flow rates through the glycol loop, and PV powered and controlled DC circulating pumps to ac pumping systems with differential controllers.

**One Pump vs. Two**

Most indirect systems in North Carolina have two pumps, one on the collector loop and one on the potable water loop. The pumps used in these indirect systems, which are under pressure, only have to overcome the dynamic head or pressure due to the resistance of the fluids flowing through the loops. Therefore, they can be pretty small, often a 1/40th HP pump or smaller is adequate, although a 1/25th HP is typical. A small (≤ 1/40th HP) bronze or stainless steel pump should be used on the potable loop. As mentioned before, the glycol loop pump can be cast iron, although bronze or stainless are reported to last longer. Two 5 Watt DC pumps (available from Ivan Labs, AET, or AAA) could be used and both could be powered by a single 10 Watt PV module. Chart 3 shows how this system heats the potable water in the tank. The storage tank water gets mixed quickly with 2 pumps, eliminating temperature stratification within the tank. In our tests this slowed the production of hot water available in the top of the tank, but produced a higher average tank temperature by the end of the day.

A one pump system that thermosyphons on the potable water side will maintain a temperature stratification in the water tank (Chart 4). This improves the efficiency of the collector and results in quicker water heating.

Chart 5 shows a comparison of these two system types. On 5 test days the double pump system produced hotter average tank temperatures at the end of the day by 5 to 9.5˚F or about 6%. However, when one considers the extra initial cost (about $100) and the operating cost (about 200 Watt-hrs/day in summer for a 1/40 HP pump) the small increase in performance may not be worth it. With a one pump system be sure to have a properly functioning air vent at the highest point of the solar heated water return line and keep things as hydrodynamic as possible. Don't put a check valve or flow meter in the potable water loop. Use 3/4 inch piping and a minimum of fittings. If delivering the hot water to the top of the tank by natural convection, keep the height of the delivery pipe as close as possible to the top of the tank.

**Chart 3: Two Pump Glycol System water tank temperature in °F**

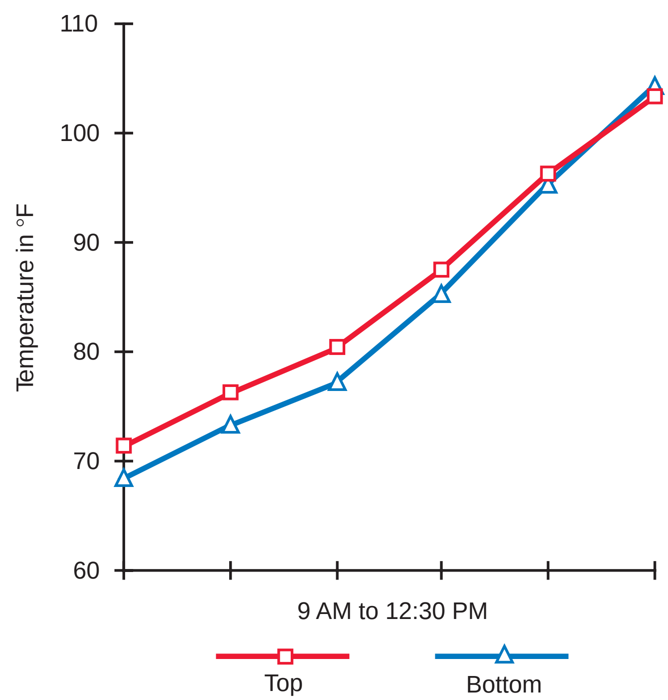


**Chart 4: One Pump Glycol System**
**water tank temperature in °F**

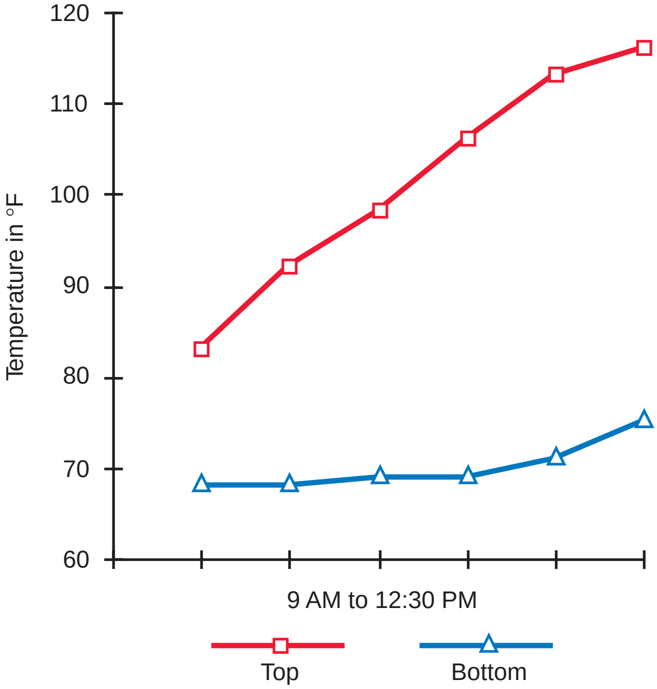
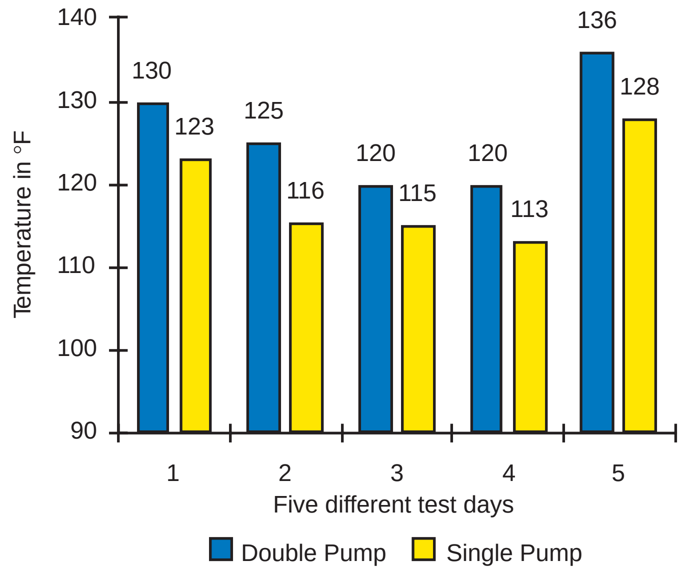
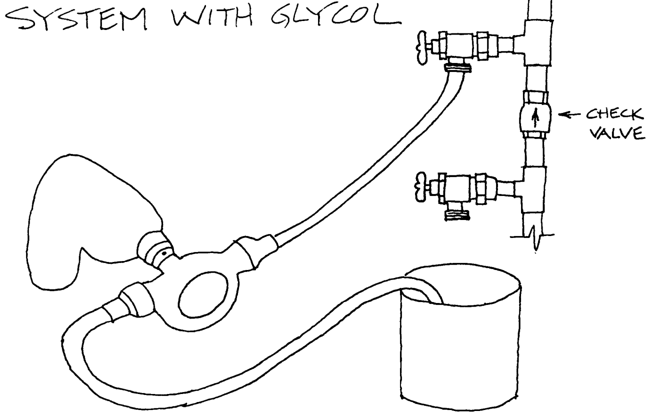



**Chart 5: Number of Pumps**
**daily average tank temperature**




**Single Wall vs. Double Wall Heat Exchangers**
Single wall exchangers have one layer of copper between the glycol fluid and the potable water. This is a material and energy efficient design. However, if a leak develops the glycol fluid could contaminate the potable water. This should not really be a major problem because propylene glycol, unlike the ethylene glycol used in most automobile radiators, is not toxic. Propylene glycol toxicity has been reported only rarely and in unusual circumstances, such as intravenous injection. It is used in medicines, cosmetics, and food products as an emulsifying agent. And even if it was a little toxic, the hot water would not normally be drunk, the quantity is relatively small, and the problem would be easily identified by monitoring the pressure gage. Also, the house water pressure normally exceeds the pressure in the collector loop, which would inhibit leaking of the glycol into the potable water.

FIG 4: FILLING SYSTEM WITH GLYCOL




A growing number of consumers are concerned about exposure to toxic materials in the home and seem to be more comfortable with the double wall concept. Some state plumbing codes require double wall exchangers.

The double wall exchangers provide an extra margin of safety in case a leak develops in the anti-freeze loop. There are two layers of copper between the glycol fluid and the potable water. But do they sacrifice a lot of efficiency by emphasizing safety? This was a question we wanted to try and answer.

The double wall heat exchanger we used was purchased from AAA Solar. They have a great catalogue with a lot of good information about designing solar water heating systems and many good products for sale. Their double wall exchanger that we tested is called the Hot Rod. They have a new improved unit called the Quad Rod which we have not tested. The commercial single wall exchanger we tested was purchased from AET. Both companies offer a variety of sizes. We used the smallest and least expensive, a 3 foot Hot Rod which cost $87.67 and a 24 inch single wall exchanger from AET costing $95.

A single wall exchanger can be easily constructed (Figure 5) by placing a 1/2 inch copper pipe inside a 3/4 inch copper pipe with 1/2 x 3/4 x 3/4 inch tee fittings at each end. I don't know what the ideal length would be, but for a system that will naturally convect on the potable side I would make the exchanger about the same length as the tank height. The 1/2 inch copper

Above: A DC system without check valve.

tubing should be longer than the 3/4 inch tubing so it can be slid through the 1/2 inch ends of the tee fittings. The shoulder inside the 1/2 inch end of the tee fitting needs to filed down a little. Clean, flux, and solder the two fittings and the tubing together and that's all there is to it. We have built and successfully used one of these but have not compared it to store bought units.

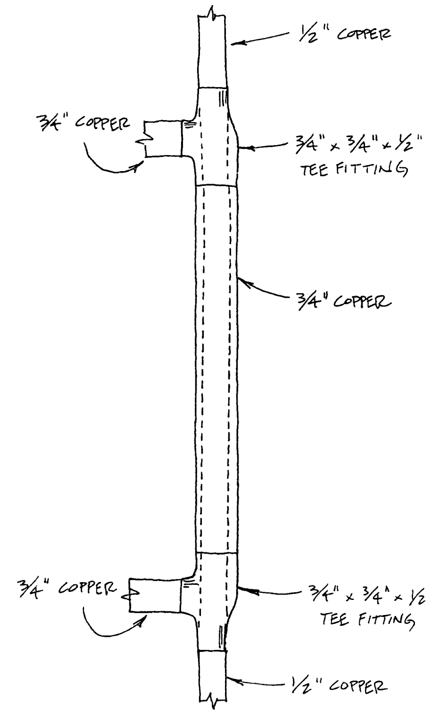
Chart 6 illustrates the results from 8 test days comparing the AET single wall exchanger to the AAA Hot Rod double wall exchanger. The average tank temperatures were from 1 to 7° F higher in the system using the AET single wall exchanger, a difference of about 3%. Both systems were using a pump only on the glycol loop. One of the most surprising results of our recent solar water heating investigations was how well the Hot Rod double wall exchanger performed. It exhibits good performance, universal code compliance, and extra safety. It also costs less than AET's. Their new Quad Rod may be even better.

**Flow Rates**

How fast the fluids should flow through a solar water heating system is a question anyone who installs a system will ask themselves. The answer depends on whether the system is a direct or indirect and, if indirect, what loop is being considered. Flow rates should be slower in direct systems and on the potable loop of an indirect system connected to an external heat exchanger. The flows in an active system can be regulated by a flow meter and ball valve or preferably by a properly sized pump. The Florida Solar Energy Center recommends 1/2 gpm for each 40 square feet of panel area, or .0125 gpm per square foot of collector area. ASHRE recommends .03 gpm per square foot of collector area for maximum collector performance. Our most recent test examined the performance of two single pump indirect systems with single wall external heat exchangers. One of our systems had approximately 1/2 gpm flow and the other 2 1/2 gpm through the collector loop or .04 and .20 gpm per square foot of collector. Both rates examined were faster than recommended.

Our Taco flow meters made it difficult to measure below .5 gpm so we didn't go below this flow rate. The potable water circulated slowly through the exchanger by natural convection and was not measured because an affordable meter would inhibit the natural convection flow and not be sensitive enough. The flow rates examined did not seem to have much affect on performance. There was only a 1° F difference favoring the 2.5 gpm system. I believe this difference could easily be explained by some other unaccounted difference in the two systems. A recent masters thesis by Thornbloom (1992) found that flow rates through the collector loop didn't significantly affect performance. Slower flow rates don't require as large a pump. The smaller pumps cost less to purchase and operate.

FIG 5:
HOME MADE HEAT EXCHANGER




Research demonstrates that slow flow rates (around .25 total gpm or .01 gpm per square foot of collector area) on single tank direct systems improves performance by 20 to 30%. There is less mixing of the water in the tank. The water stays stratified and the collector feed water at the bottom of the tank stays cool longer. This cooler water more effectively picks up collector heat.

**DC vs. ac**

DC pumps are available for solar water heating systems that require as little as 5 Watts of power. We are currently using El-Sid pumps from Ivan Labs Inc. They have the best prices I have found and 3 models are available. The pumps are capable of 1.7 to 3 gpm at full sun (317 Btu/hr or 1000 Watts per square meter). They all use the same March 809 bronze pump, but have different size drivers; a 4-5 Watt, 5-7 Watt, and a 10 Watt. We used the largest driver with a

**Chart 6: Exchanger Type**
**daily average tank temperature in °F**

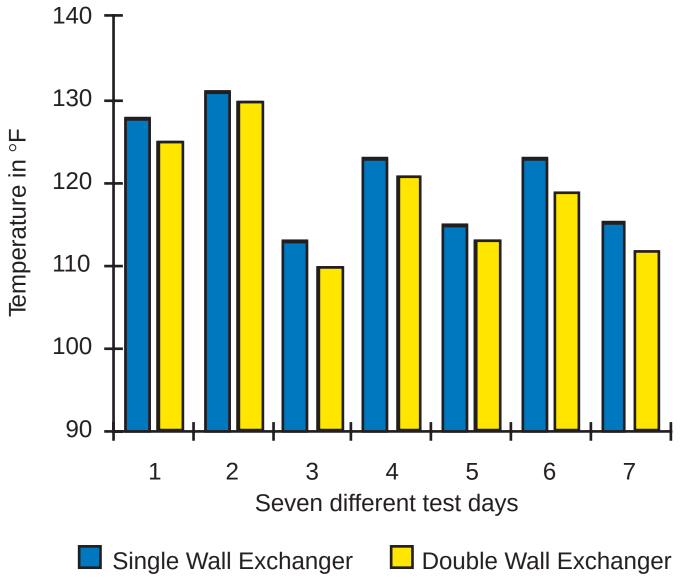
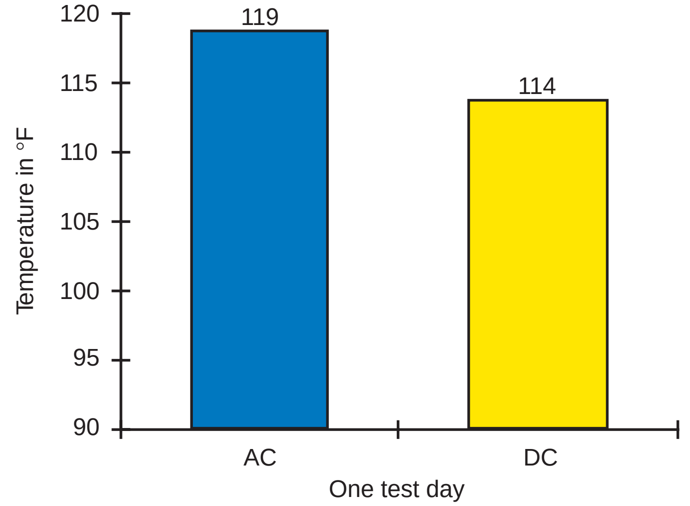



**Chart 7: AC vs. DC**
**daily average tank temperature in °F**




Siemens M10 10 Watt module for this test. It was purchased from Hutton Communications for $128.00. A 5 Watt module such as the Solarex SA-5 is all that is required for their smallest pump. This system design eliminates the need for a controller. We have collected data on three different days and our single pump ac systems have consistantly out performed our "identical" DC systems by a small amount. Chart 7 shows the greatest difference observed in the average tank temperatures at the end of a test day. I think the slight performance differences may not be related to the ac/DC variables but to slight differences in our elderly collector efficiencies. We need to mix our components up and try this again or test our collectors.

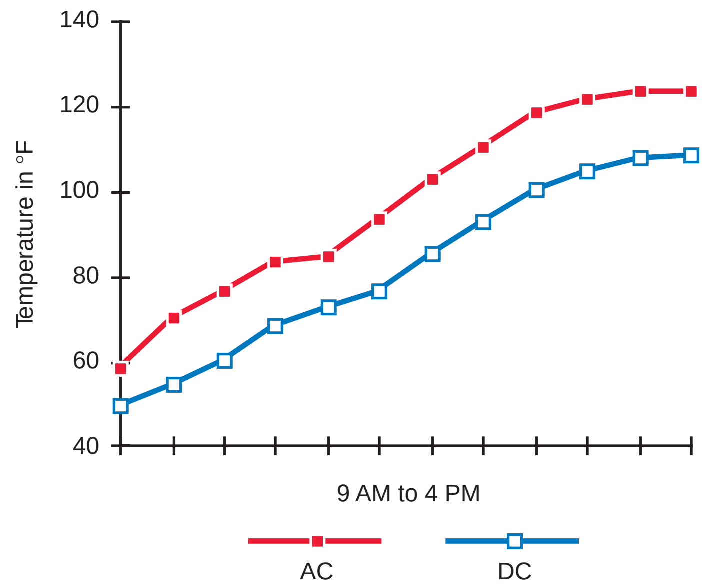
When using a PV powered and controlled DC pump, use a Zomeworks floating ball check valve in the return piping (from AAA) or a vertical check valve with the spring removed in the supply piping. The AET check valves can be screwed apart and the spring easily removed. The flow path should be as hydrodynamic as possible with 3/4 inch copper tubing and a minimum of turns and fittings. Make sure a properly functioning air vent is set at the highest point in each loop.

### Cost Comparisons

The initial cost of a solar water heating system is probably the most important consideration for someone considering purchasing a system. Fortunately for us in North Carolina we can take advantage of a 40% state tax credit, the most generous in the country. Our empirical research shows that all the common system designs work well if properly installed and the differences in performance between system types is not that significant. The drain back system was the only really poor performer and I think future tests with a larger system and better insulated drain back tank will show more comparable performance. Probably the most important aspect of system performance is getting the correct square footage of collector for the quantity of water one wants to heat. This varies depending on geographical location and system type.

I have compared the costs of the systems discussed in this article in Chart 9. I excluded the collector cost, storage tank cost, the cost of piping to and from the collector, pipe insulation, and fittings. They are approximately the same for all similarly sized systems

**Chart 8: AC vs. DC**
**top of tank temperature in °F**



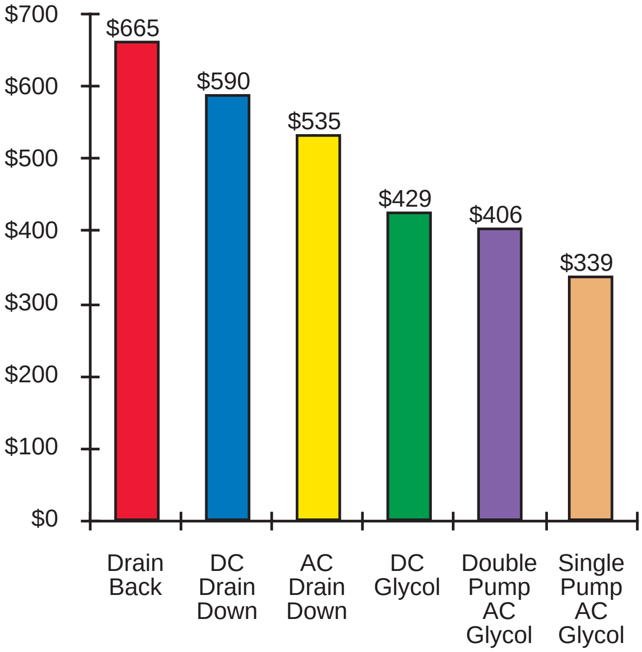
and would add about $1000 (if all new components were used) to the cost of a single panel system The costs of piping, insulation, and fittings would be approximately $300 and the same for all systems. A tank is about $200 and a new 4 x 10 foot collector about $500. All material costs used to construct Chart 9 were taken from AET, AAA, Heliotrope, or local vendors and were the best prices I could get as an educator and part-time designer and installer.

Above: Appalachian students just doing it.

The best price I have found on new collectors is about $12.50 per square foot from AET and Sunquest. If they have to be delivered add up to $2.50 extra per square foot. AET advertises a 4 x 10 foot black chrome collector for $507.00. This equals close to 50% of the total material cost. There are a lot of used collectors on the market. Many become available from people who are having their roofs re-shingled. I have purchased perfectly good collectors for about $1.25 per square foot or in some cases get them for nothing.

As Chart 9 depicts, the glycol systems are less expensive than the others. The material cost for the cheapest is $339. Adding $300 for piping, fittings, and insulation the total cost is about $638, minus collector and storage tank. This system could pay for itself if electricity were used for water heating in 3 to 4 years. A reasonable total cost for a single panel installed system with all new components including a tank would be $2000 ($700 for installation and $1300 for materials). With a 40% tax credit the installed price for a new system would be about $1200. This system, if properly installed, will provide between $200 and $300 worth of hot water, at current electrical rates, per year and will last for 20 years or more. The system cost could be reduced by using a “second hand” collector, a “snap disc switch” instead of a differential controller, and by using a home made heat exchanger. We have tested snap disc switches and they seem to work well. They are thermally actuated switches that turn on at 110˚ F and off at 90˚ F and are available from AAA for $28.

**Chart 9: Cost Comparisons excluding collector, tank, and piping**




The drain back system was the most expensive in my analysis. It requires a drain back tank which cost $354 from AAA and also two pumps. The collector loop pump normally needs to be larger and more expensive to overcome the static and dynamic heads in the unpressurized drain back design.

The labor for installation is a consideration and can equal or exceed the cost of materials. A ground mounted panel, PV controlled, single pump indirect glycol system with an external heat exchanger took me 50 hours to install. It was my system with these components and I was working alone. I could probably do it faster the second time. The Heliotrope drain down direct systems would be less time consuming to construct, especially with the new Solar Sidebar.


Above: Completing the connections between the exchanger and collector.

**Conclusion**

Solar water heating technology is affordable, works well if properly designed and constructed, and the components are readily available. The direct solar water systems have been the best performers in our tests. The average tank temperature for the direct systems was 6% higher than the single pump, single wall exchanger, glycol systems tested; and 19% higher than the drain back system. The major drawbacks of the direct system for colder climates are freeze protection and possible clogging of collector tubing if potable water has high mineral content or is "hard". The Heliotrope HG-Spool and Solar Sidebar drain-down valves promise reliable freeze protection and the superior performance of the direct system.

The indirect glycol systems with external heat exchangers seem to be the best value and offer excellent performance and reliability. In our tests on indirect systems with external heat exchangers, two pumps produced about 6% hotter water than a one pump system. The AET single wall exchanger produced 3% hotter water than the AAA double wall, the collector flow rates examined did not significantly affect system performance, and on the three days we compared ac to DC, the ac system produced 4% hotter water than a PV powered and controlled DC system. Future projects will continue to compare the PV powered and controlled DC pumping systems with ac systems and will compare AAA's Quad Rod exchanger and our home made exchangers to those already tested. Many other questions can and will be addressed.

Designing and building solar water heating systems is a great educational activity for students, filled with problem solving and hypothesis testing situations. Students found this activity to be enjoyable, challenging, and a great learning experience.

**Access**

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"Solar Water and Pool Heating: Design and Installation Manual (1992)", Florida Solar Energy Center, 300 State Road 401, Cape Canaveral, FL 32920 • 407-783-0300

AAA Solar Service and Supply Inc., 2021 Zearing Ave. N.W., Albuquerque, NM 87104 • 800-245-0311 • WWW www.rt66.com/aaasolar • E-Mail: aaasolar@rt66.com

American Energy Technologies, Inc., PO Box 18650, Green Cove Springs, FL 32043 • 800-874-2190

Heliotrope General, 3733 Kenora Drive, Spring Valley, CA 91977 • 619-460-3930

Pace Scientific, 1401 McLaughlin Drive, PO Box 10069, Charlotte, NC, 28212 • 704-568-3691

Blue White Industries, 14931 Chestnut Street, Westminster, CA 92683 • 714-893-8529

Hicks Water Stoves & Solar Systems, 2541 South Main Street, Mount Airy, NC 27030 • 910-789-4977

Camco Manufacturing, PO Box 18865, Greensborro, NC 27419 • 910-668-7661

Ivan Labs Inc., 305 Circle West, Jupiter, FL 33458 • 407-747-5354

Hutton Communications, 5470 Oakbrook Parkway Suite G, Norcross, GA, 30093 • 800-741-3811

Sunquest, 1555 Rankin Ave., Newton, NC 28144 • 704-465-6805

ANANDA POWER TECHNOLOGIES

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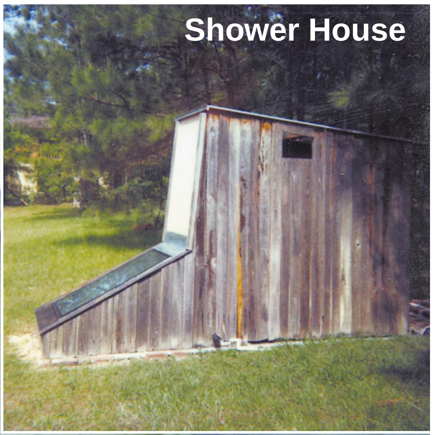


Shower House

# How to Build & Install Your Own Thermosyphon Solar Water Heater

Perry A. Bocci



Wall Mount Design

Yard Mount Design

The thermosyphon solar water heater is one of the simplest, most economical, and, I believe, the best type of solar water heater. It's a passive system, meaning that it has no mechanical or electrical devices that make it work. Only the sun's energy is needed to heat the water in the solar collector and circulate that water through the holding tank.

Thermosyphon is defined as "a hydraulic system whereby the circulation of fluid is caused by a temperature differential in the fluid." Figure 1 illustrates this principal. The solar collector is facing south at an angle of 30° under direct sunlight. The holding tank is behind and above the solar collector. The tank and the solar collector are connected by the piping as shown. The system is full of water under pressure with no air pockets. Standard household water pressure is about 50 psi.

Direct sunlight heats the water inside the solar collector. As the water is heated, it rises and circulation begins. The rising hot water flows up the solar collector outlet pipe and into the holding tank. Cooler water from the bottom of the tank flows down the inlet pipe and into the solar collector. The circulation of water between the solar collector and the tank will continue as long as direct sunlight falls on the solar collector, heating the water inside. The hot water will rise to the top of the tank and stay there until you use it. The holding tank

should be well insulated to store the hot water for at least one day. No pumps or electronic controls are needed to make this system work, just some basic rules of physics properly applied.

The most basic principal we're using here is that heat rises. By carefully following the rules and instructions provided here, you will be able to design and build your own thermosyphon solar water heater to suit your particular hot water needs.

**The Solar Collector**
We've all had the experience of walking out to our car on a hot summer day as it was parked with the windows rolled up and under direct sunlight. When we opened the door, a blast of hot air was felt and perhaps the seats were too hot to sit on. That's solar energy at work, with your car being the solar collector. The sun's rays passed through the window glass and heated up the inside of the car.

The solar collector in a solar water heater works the same way, but produces much higher temperatures. The sun's energy passes through the glass cover plates and heats the water that's in the piping inside the collector. The water is passing through the solar collector very slowly, is heated, then flows to the holding tank which stores the water until you use it.

**Circulation**
Water must circulate from the tank, to and through the solar collector, then back to the tank, and so on, until all the water in the tank is heated. If the solar collector is too small in surface area it won't be able to heat all the water in the tank. If the solar collector has more surface area than needed, it will heat up all the water faster and hotter. There are different ways to circulate the water through the solar collector. Many expensive solar water heaters on the market today use pumps and electric controls to circulate the water when the sun is shining. They work well until there's a mechanical breakdown, which is inevitable. Then it's usually a costly experience to get the part replaced so you can have solar hot water again. With the thermosyphon solar water heater, no pumps or electronic controls are needed. It is designed so that the heat energy from the sun causes circulation without the help of a mechanical device, and it is simple and maintenance free.

**Sizing the Solar Water Heater for Your Needs**
For maximum energy efficiency and savings, the solar water heater should heat and store enough hot water each solar day to last overnight and satisfy your needs. With this in mind, proper sizing of the holding tank and the solar collector is essential. You must calculate how much hot water your household uses each day, and

**Figure 1. Piping Layout for the Thermosyphon Solar Water Heater.**

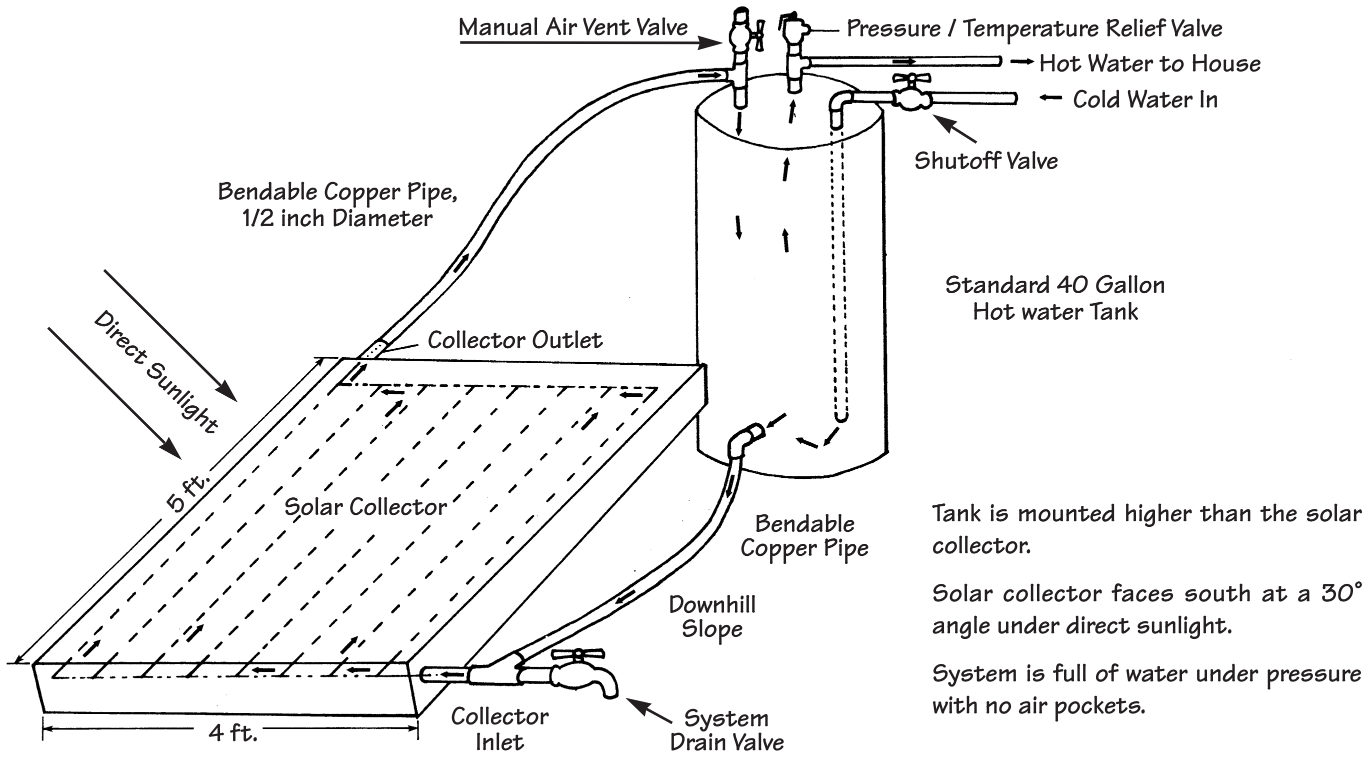
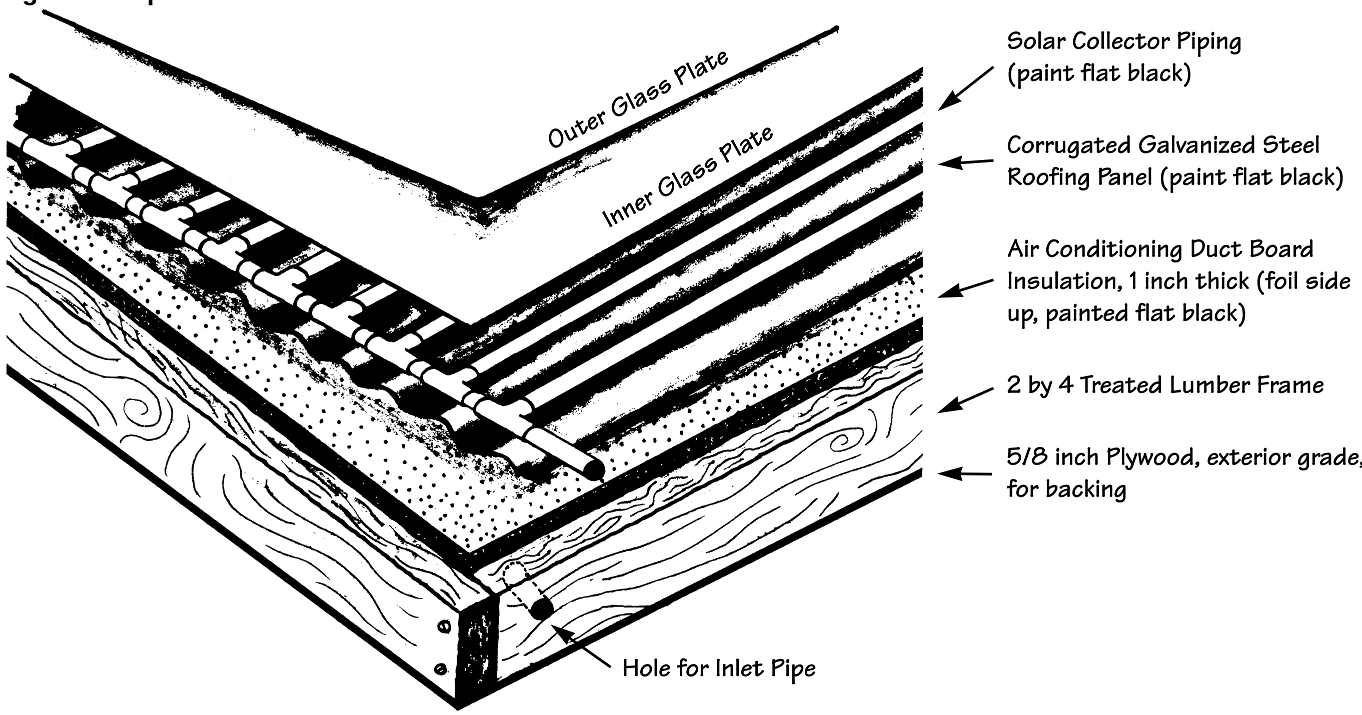


**Figure 2. Exploded view of solar collector**

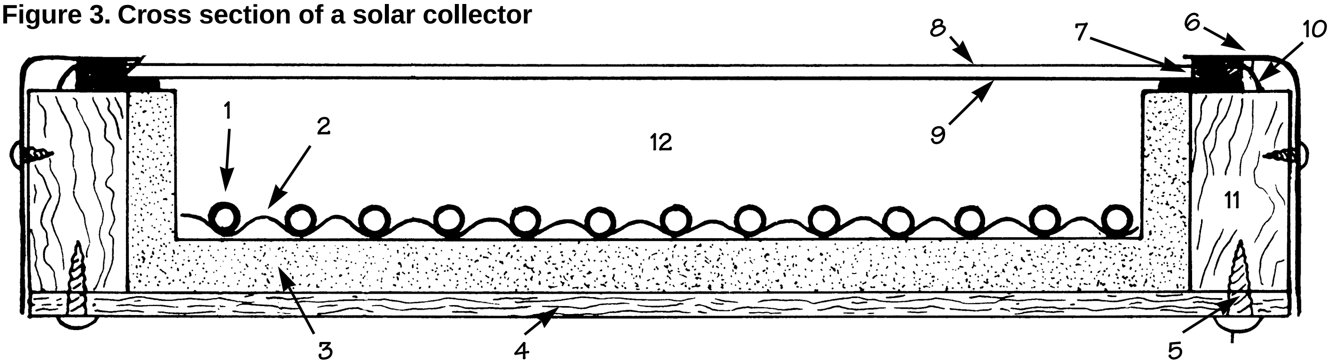



then size the tank and the solar collector accordingly. Everyone has different water use habits, but a good average to go by is 20 gallons of hot water per day per person. For example, a family of four would need an 80 gallon tank, a family of five a 100 gallon tank, or a family of two a 40 gallon tank.

Once you know how many gallons of hot water will need to be heated, then you can size the collector. It must have enough surface area exposed to the sun's energy to be able to heat all the water in the tank in about six hours, or one solar day. With this collector design you can expect to heat two gallons of water with each square foot of collector each solar day.

The solar hot water heater described in Figure 1 is 40 gallons in tank capacity and the collector has 20 square feet of surface area exposed to the sun's energy. The

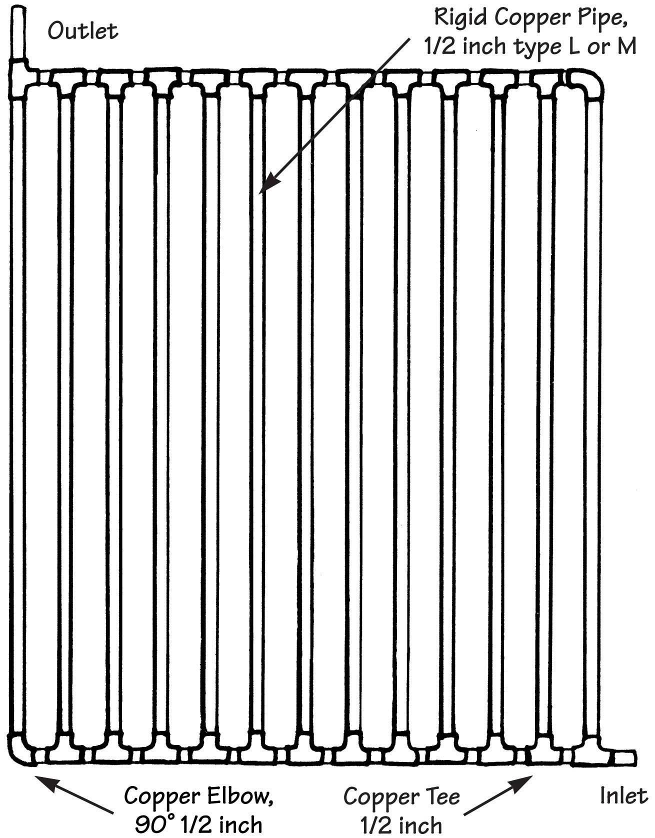
**Figure 3. Cross section of a solar collector**




1 Copper pipe, 1/2 inch rigid, type M
2 Absorber plate, 30 gauge galvanized steel, corrugated
3 Insulation, at least 1 inch rigid A/C duct insulation
4 Plywood, 1/2 inch exterior grade
5 Screws
6 Sheet metal flashing, aluminum to cover perimeter of the collector protecting the wood frame
7 Rubber weatherstrip gaskets, around the perimeter of the glass
8 Outer glass cover plate
9 Inner glass cover plate, for extra efficiency and higher temperature
10 Sealer, collector is made air tight with silicone sealer around the perimeter of the glass, pipe inlet, and outlet
11 Lumber, 2 by 4 inch stud for perimeter framework
12 Trapped air spaces, inside the collector and between the two glass cover plates.

In direct sunlight, temperatures inside the solar collector can be as high as 200° F., depending on solar intensity.

**Figure 4. Solar collector piping**




heater that you will build for yourself may be larger or smaller. What's important is that the building techniques and general rules outlined here are carefully followed.

| Tank Capacity | Collector Sq. Feet | Collector Dimensions |
|---|---|---|
| 20 gal | 10 | 3 ft X 3.3 ft |
| 30 gal | 16 | 4 ft X 4 ft |
| 40 gal | 20 | 4 ft X 5 ft |
| 50 gal | 25 | 5 ft X 5 ft |
| 60 gal | 32 | 4 ft X 8 ft |
| 80 gal | 42 | 6 ft X 7 ft |

**Materials**

How much you spend on materials for your solar water heater will depend on the size of your system. An 80 gallon solar water heater will cost more to build than a 40 gallon, but certainly not double the cost. $500 is an average figure based on a family of three or four and using a 60 gallon solar water heater. You may spend more or less than that depending on your needs. If you already have or can salvage some of the materials you're going to save even more.

Quantity is not mentioned in the materials list because your heater may be bigger or smaller than these systems. Using these designs, you can calculate the amount of materials needed for your particular system and buy accordingly.

Lumber, exterior grade, 2 by 4 studs

Plywood, 5/8 inch exterior grade, 4 by 8

Common nails or wood screws

Glass cover plates (window glass will work)

A/C duct insulation, rigid 1 inch minimum, foil on one side

Pipe insulation, 3/4 inch thick

Tank insulation, fiberglass wrap-around

Copper pipe (for solar collector), rigid 1/2 inch, type M

Copper pipe (for use outside the collector and for between collector and tank), 1/2 inch bendable

Copper pipe fittings, elbows, tees, threaded fittings, etc.

Valves, brass hose bib type

Relief valve (for hot water tank)

Roof panel, corrugated and galvanized (for absorber plate)

Duct tape, aluminum (for insulation seams)

Silicone sealant, caulk

Rubber weatherstrip tape

Paint, flat black, high temperature

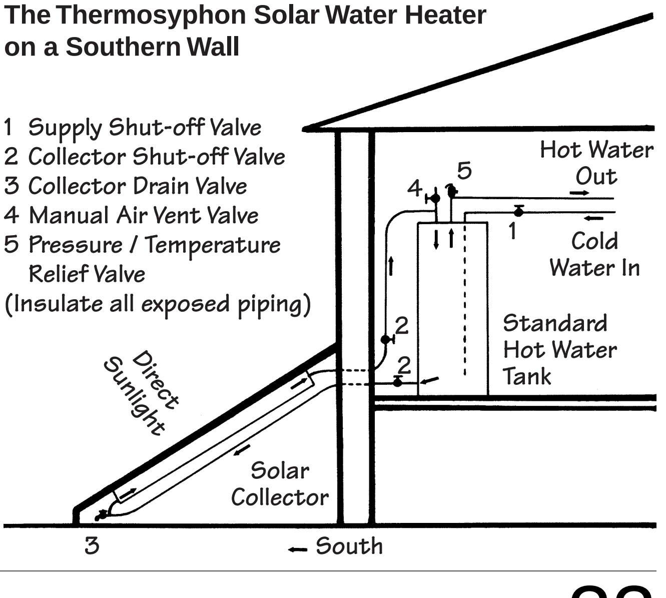
Wood preservative

Aluminum flashing, 6 inch (to protect collector wood)

Copper strap, 1/2 inch (to fasten collector pipe to absorber plate)

Hot water tank, standard electric (use electricity for back-up hot water only)

**The Thermosyphon Solar Water Heater on a Southern Wall**



**General Rules**

1. Basic plumbing and carpentry skills are required to build this system, especially the skill of soldering copper pipe and copper fittings together using a propane torch and 95/5 solder, with flux.

2. Solar collector must face south

3. For maximum year round gain, the collector angle should match your latitude.

4. Solar collector needs six hours of direct sunlight per day to heat all the water in the holding tank.

5. Solar collector won't work in the shade.

6. During freezing weather conditions, all water must be drained from the solar collector, or freeze damage will occur.

7. Use standard hot water heater as the holding tank for your thermosyphon solar water heater. When adequate solar energy is not available use the heat source in the tank as back-up.

8. Use only copper pipe and copper pipe fittings for this system. Do not use any PVC or plastic pipe in this system.

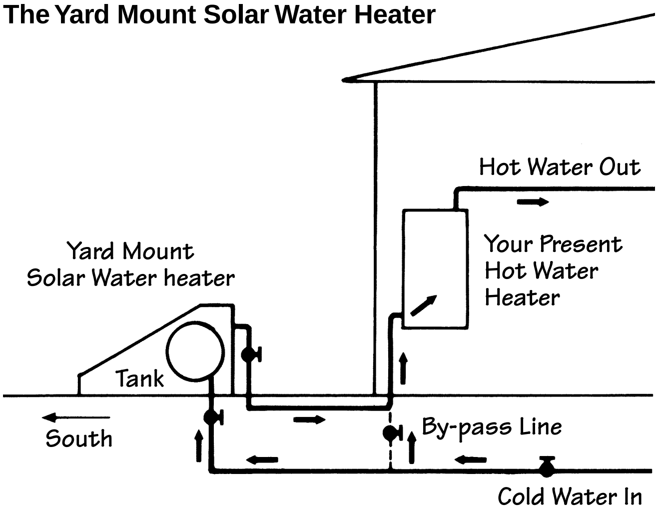
9. In a thermosyphon system, the tank must be behind and above the solar collector and piped as shown in figure 1.

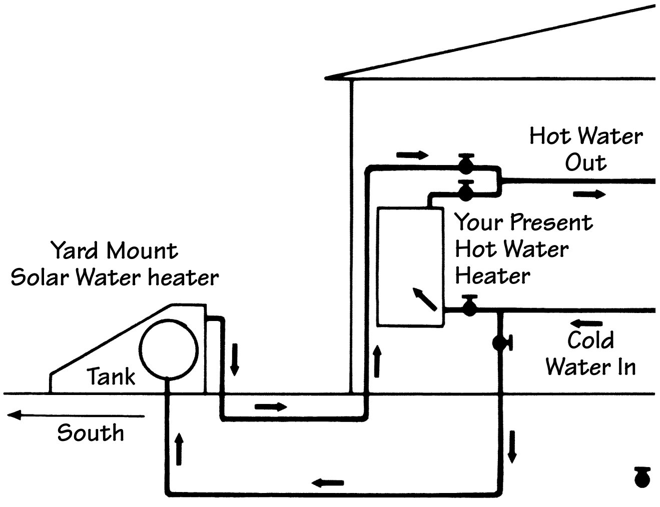
10. Insulate all exposed pipe with foam pipe insulation, 3/4 inch i.d. by 3/4 inch wall.

12. For the thermosyphon solar water heater to work properly, it must be full of water under pressure with no air pockets inside the system. A gate valve is installed at the highest point in the system (see figure 1) to manually vent air from the system during initial fill up.

13. Before you buy any materials, make a drawing of your system and estimate the amount of lumber, pipe and fittings, glass, etc. that you will need. See "Sizing the Solar Water Heater."

**The Yard Mount Solar Water Heater**




### The Yard Mount Design in conjunction with your existing hot water Tank, Plan 1

Energy can be saved by supplying your existing hot water tank with solar heated water. To do this, disconnect the supply water to your existing hot water tank and pipe it to the yard mounted solar water heater. The solar heated water that leaves the yard mount design is piped to the bottom of the tank in your house, supplying preheated solar hot water.

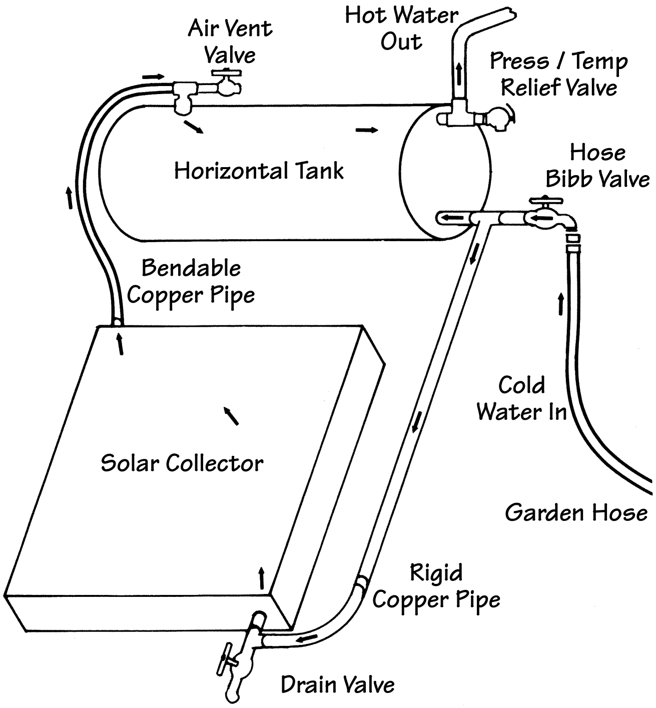
Insulate all piping with pipe insulation. Install valves where needed. The yard mounted solar water heater will need to be drained during freezes, so a by-pass pipeline is required (see diagram).

### The Yard Mount Design in conjunction with your existing hot water Tank, Plan 2

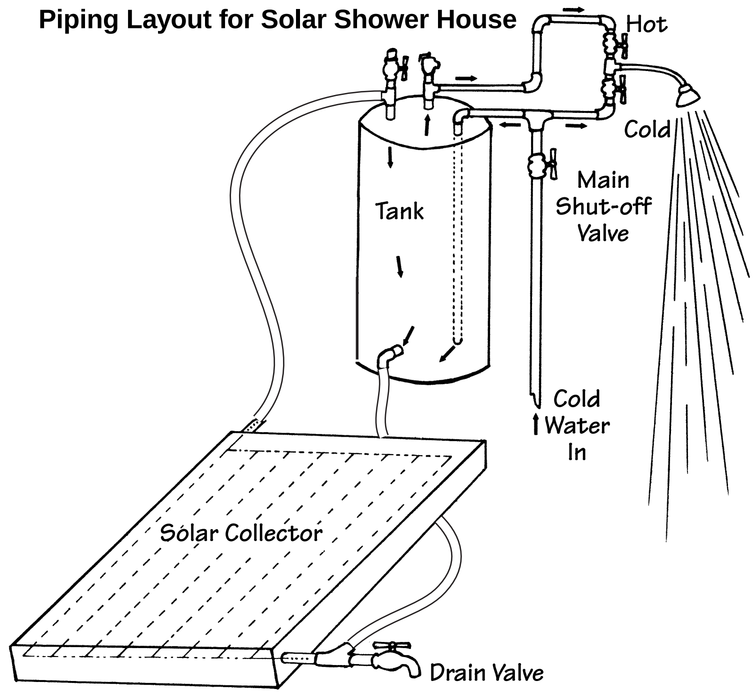
With this piping configuration, you can choose which water heating system to use by turning the appropriate valves. On good solar days, you can use only the solar heater and turn off your existing conventional heater. On days when the sun isn't shining or during freezing weather, the solar heater can be turned off while using your existing conventional heater (see diagram).

Always drain the heater during freezing weather. Insulate and bury the piping between the solar water heater and your house.

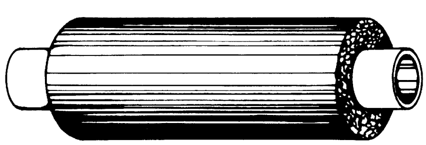
**Piping Layout for Yard Mount Design**




**Piping Layout for Solar Shower House**




**Insulate all exposed piping with pipe insulation, 3/4 inch wall.**



**Access**

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TRACE ENGINEERING

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# Doing a Load Analysis: *The First Step in System Design*

Benjamin Root



It's not that we really care about electricity. We don't even care about the appliances that the electricity powers. Our wants and needs are even more basic than that. We want to read after dark, hear good music, and learn about what is happening in the world. We want water on demand and unspoiled food. We don't need the electricity like we don't need the drill. What we need is the hole.

Electricity is merely a tool used to meet our needs and wants. When planning a renewable energy (RE) system it is important not to lose sight of what our needs actually are. Only once our needs are defined can we then begin to design an RE system to meet them. We must analyze each need and determine how much energy it takes to meet that need. Long before we start comparing prices on photovoltaic modules we must first create a list of needs called a "load profile." This article will first discuss some important considerations in choosing appliances to meet certain needs. Then we will go through a step by step discussion of the various elements in a load profile.

**Why Do a Load Profile?**
RE systems are expensive. Costs to produce one's own electricity from renewable sources average between $0.25 and $1.15 per kilowatt hour (kWh). This is many times the price of buying power from the electric utility. Off grid, it is a waste of money to use more energy than we need to and a waste of money to produce energy that is not used.

If done correctly, your load profile's average daily kWh figure can be quite accurate. Careful load analysis can assure that we size our RE system appropriately.

**Which Loads are Appropriate Uses for Electricity?**
Most of us need to eek out as much functionality from as little energy as possible. For example, electricity is an expensive way to produce thermal energy. The electricity needed to provide space heating is generally cost prohibitive. Passive solar, wood heat, and propane furnaces are all much more practical. Domestic hot water heaters and cookstoves are also best powered by passive solar, wood, or gas.

Certain loads can be powered by electricity or by other sources. Refrigeration is a good example. Propane refrigerators are available but have their own set of pros and cons. In an energy efficient home the electric refrigerator (even the energy efficient kind) is usually the largest single load. Many RE systems use electric well pumps, but wind-powered mechanical pumps have effectively provided domestic water for generations. These choices are ours. Do we need a 1,200 watt hair dryer or will a towel do just as well? Is using candles or kerosene for light really a smart (or safe) alternative to compact fluorescents?

Some needs are surprisingly appropriate for use with renewable energy systems. Power tools, microwave ovens, toasters, and other kitchen appliances can draw a lot of power and are often mistakenly considered to be too much for an RE system. Actually, these appliances are used for short periods of time and the energy consumed is rather small.

**Why Pay Extra for Efficiency?**
It might sound like we must do without certain luxuries in order to live with a renewable energy system. This is not the case! RE systems can provide the same amenities that our city cousins enjoy. The trick is to carefully choose how these luxuries are implemented. The most cost effective way to produce one's own energy is to first reduce one's needs for that energy. Richard Perez has a saying that sums it up quite well, "Every watt not used is a watt that doesn't have to be produced, processed, or stored." When buying grid power we can dip into a limitless supply and pay as we go. But with RE systems the cost of the energy is the up front cost of expensive system components. Choosing energy efficient appliances is cheaper than renewable energy system components.

For example, compact fluorescent light bulbs have improved immensely. The light is natural colored, flicker free, and very efficient. A 15 watt compact fluorescent produces the same amount of light as a 60 watt incandescent bulb—at one fourth of the power consumption. They cost about $22 but last 10,000

hours, about ten times longer than a standard incandescent bulb. More important is the money saved by power that doesn't have to be produced. Saving 450 kWh of electricity, at $0.65 per kWh (a hypothetical middle ground cost for RE based on a well designed photovoltaic system with generator back-up), over the bulb's lifetime translates to about $292 dollars. More than enough savings to cover the $7 price difference between one compact fluorescent and ten incandescents!

Refrigeration is another good example of energy efficiency paying for itself. It is often the largest load in a RE-powered home. A sixteen cubic foot Sun Frost fridge may cost $2,500 but uses only about 540 watt hours each day. A typical major brand, non-efficient fridge may cost only $600 but will use 1,500 watt hours per day. Assuming $0.65 per kWh for an RE system, the electricity to operate the non-efficient fridge for ten years costs about $3,558. The electricity to operate the Sun Frost for ten years costs about $1,281. The difference is $2,277 worth of renewable energy system components that never need to be purchased, and more than covers the $1,900 difference in price.

**"Every watt not used is a watt that doesn't have to be produced, processed, or stored."**

A good rule of thumb says that for every extra dollar spent on energy efficient appliances, three dollars will be saved in energy system components. It becomes obvious that before one dollar is spent on photovoltaic panels, wind generators, or hydro turbines we must streamline our electrical demands.

### Are Phantom Loads Really a Big Deal?

If you read many *Home Power* articles then you know phantom loads are one of our biggest pet peeves. Phantom loads use electricity while providing nothing in return. A phantom load is any appliance that consumes power even when it is turned off. While they may seem small they use power twenty-four hours a day. A 4 watt phantom load can cost about $22 a year on an RE system, a lot for an appliance that is supposed to be off.

Any appliance with an electronic clock or timer is a phantom load. If we want a clock we should use one that is mechanically wound, battery powered, or even electrical. But a clock in an appliance keeps the appliance's entire power supply "alive" just to tell us the time. Very inefficient.

Appliances with remote controls remain alive while waiting for the "on" signal from the remote. Any appliance with a wall cube is also a phantom load. A wall cube is a small box that plugs in to an AC outlet to power appliances. Wall cubes consume 20 to 50% of the appliance's rated power even when the appliance is off.

**"One human One Light"**

Most modern TVs, VCRs, stereos, computers, Fax machines, and other electronics are phantom loads. They may contain a transformer, much like a wall cube, that stays alive even when the appliance is off and consumes between 50 and 200 watt-hours per day. They may also contain a filter or line conditioner, to clean up incoming power for the sensitive electronics inside, consuming 8 to 40 watt-hours per day.

Modern televisions have an "instant on" feature so we don't have to wait for the picture tube to warm up. We might as well call these TV's "always on."

The most direct way to overcome phantom loads is to unplug the appliance when it's not in use. A more convenient technique is to use a switched plug strip. These short extension cords with multiple receptacles allow us to cut all power to multiple appliances with one flip of a switch.

Use care when shopping for appliances that will run on a renewable energy systems. Models that are not phantom loads often have the fewest bells and whistles but are the least expensive.

For more information on detecting and avoiding phantom loads see *HP* 55, page 36.

### How to Do a Load Analysis

On page 41 is a load profile form. It is available as a Microsoft Excel spreadsheet on the Home Power web site (http://www.homepower.com). Every appliance in your household that receives regular use should be logged onto this form. When completed you will have an accurate estimate of your average daily kWhs used. This is the foundation on which to build an RE system.

You may be planning for a future RE system at a home that is not yet completed or fully inhabited. Is is important to estimate your future loads as accurately as possible. Try to be realistic about your lifestyle and energy usage habits (Americans watch twice as much TV as they think they do). Be aware of possible appliance purchases in the future, like for growing families. Remember obscure loads such as well pump, satellite dish, garage door opener, etc. The accuracy of

the final estimate is dependent on the accuracy of your initial data.

In a load analysis we evaluate a variety of parameters for each appliance. By combining this data we will be able to see this appliance's impact on your energy needs as a whole, and in comparison with other appliances. What follows is a discussion of each parameter (vertical column on the form) and how to obtain the data.

**Column A: Appliance**
Simply, what appliance are you testing?

**Column B: Number**
How many of these appliances? An example of multiple identical appliances is lights. There is no need to list every light bulb in the house separately. Richard Perez has a super analogy of one light for every member of the household. Imagine each person has a light that follows them around the house as they move. This is just an analogy, and until technology improves, it is up to each person to throw the switches to get their light to follow them. Ideally then, a three person family should be able to enter 3 in this column for personal lighting. Lights of different wattages should get separate entries. A light on a timer in the driveway should get its own entry, as should a night-light that stays on all night in the hall.

**"Every dollar spent for an efficient appliance saves three dollars in renewable energy system components."**

**Column C: Load Voltage**
At what voltage does this appliance operate? RE systems are moving away from 12 Volt systems. Modern RE-powered homes often run on 24 or even 48 Volt systems. Some DC appliances are available for 12 Volt, less so for 24 Volt. Most inverter-powered AC appliances run at 110 Volts (117 Volts rms) but we must not forget about the indispensable 220 volt power tool.

**Column D: AC or DC**
Does this appliance operate on inverter power or directly from battery power? Inverters consume power by just being on. However, many renewable energy system users are finding that the advantages of constant ac power easily offset inverter losses. Here at Home Power we run all our communications equipment directly on DC for emergency reliability reasons.

**Column E: Inverter Priority**
Does this appliance spend a large amount of time on? The purpose of this column is to get a feel for the normal operating wattage of the inverter. If an appliance spends a good deal of time on or if we want to be sure that this appliance will always have access to inverter power, then we consider it to be an inverter priority load.

Any appliance that turns itself on and off must be an inverter priority load because we cannot control its access to the inverter. Some loads are operated infrequently and we can decide what other appliance we will allow to operate at the same time. These loads are not inverter priorities.

Later, when we are designing our RE system, this column will help us choose the size of our inverter. It will also help determine the inverter's average operating efficiency.

**Column F: Run Watts**
How much power does the appliance consume when in use? The most accurate way to determine this is to measure current through the appliance then multiply by 117 volts if it's an ac appliance. If the appliance is DC, multiply the measured Amps by the system voltage to determine Watts. Measuring Amps involves getting an ammeter in series with the load. *HP* 33 page 82 illustrates an effective little gismo for breaking into ac wiring to measure amperage.

Another technique for measuring amps, if your meter has limited amp capability, is to use a shunt. A shunt is a small resistor of known value. It, like an ammeter, must be placed in series with the load being tested. Once in place, measure voltage across the shunt, then use Ohm's law to determine the amperage. If you don't want to buy a shunt then make one out of #10 wire. One foot of #10 copper wire has a resistance of 0.001 ohms. Set your voltmeter to the millivolt scale and measure the voltage drop across the makeshift shunt. For more information on using wire as a shunt see *HP* 6 page 35. To review Ohms law see *HP* 52 page 64.

Electrical appliances display their power use data on a plate or sticker. The noted watt value represents a worst case scenario, the most power that the appliance will ever draw. We generally don't listen to the stereo with the volume all the way up (punk rockers aside), or juice marbles in the blender. If you want accurate numbers you should measure actual watts. If you can't measure then derate the sticker wattage by about 25%.

**Column G: Hours per Day**
How much is the appliance used each day? In some ways this information is easy to figure: The radio plays

| A | B | C | D | E | F | G | H | I | J | K | L |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Appliance | Qty. | Volts | AC DC | P Y/N | Run Watts | Hours /Day | Days /Week | W-hours /Day | Percent of Total | Surge Watts | Ph-L Y/N |
| Espresso Maker (example) | 1 | 117 | AC | N | 1350 | 0.20 | 7 | 270.0 | 6.8% | 1350 | N |
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**Total Daily Average Watt-hrs** ______

Inverter Priority Wattage ______ Max. ac Wattage ______ Max. ac Surge Wattage ______

every morning for forty-five minutes while you get ready for work. The washing machine takes twenty minutes to complete a cycle. Other appliances are more tricky, for example the three light bulbs for your three person family. You need to guess how much time each day that each light is on.

Some appliances turn themselves on and off automatically. Refrigerators start up when the temperature inside gets too warm. They run until they are cooled down to certain temperature when they turn themselves off. This is called a "duty cycle" and can be estimated by direct observation. Just pay attention to how often that fridge comes on and how long it stays on.

When determining energy use, the time element of column G is interconnected with the power element of column F. We can ignore duty cycle by using a recording ammeter and a stopwatch. Simply divide total amp-hours consumed by the number of hours tested to

***"If you want a clock, then buy a clock."***

obtain a constant amps rating. Multiply amps times appliance voltage (column E) to get watts (column F). Then use 24 hours per day in column G.

**Column H: Days per Week**
Do you do wash every day? Do you only watch TV on Saturday mornings? This helps determine average energy use per day.

**Column I: Average Watt-hours per Day**
Number (Column B) x Watts (Column F) x hours (Column G) x days (Column H) ÷ 7 days per week = average watt-hours per day for this appliance.

$$B \times F \times G \times H \div 7 = I$$

This amount tells us, on average, how much electricity is consumed each day by this appliance. The total at the bottom of this column tells us how much electricity we use on an average day.

**Column J: Percentage of Total Electricity Use**
Just for your information, what percentage of total electrical use does this appliance represent? Column I ÷ the total sum of column I for all appliances.

**Column K: Starting Surge in Watts**
Does this appliance have a starting surge? How much? Any appliance with a motor has a starting surge. This means that before the motor is up to operating speed it is drawing more than its rated operating power. This is especially true if the motor is starting under load. Refrigerators, well pumps, and most power tools have starting surges. Motors surge between three and seven times their rated wattage.

Other appliances that may have starting surges are TVs, computer monitors, and any appliance with an internal power supply. These loads have large capacitors that charge themselves when the appliance is first turned on. They can surge up to three times their rated wattage.

Because they are relatively short—in the millisecond range—starting surges don't make much of a difference in the amount of energy that an appliance consumes. Starting surges are important, however. Inverters must be sized to handle the starting surge of ac appliances. Battery banks must also be sized to handle the voltage depression caused by a high amp surge. Voltage depression can cause an inverter to shut down even if the inverter itself is large enough to handle the surge.

Measuring the starting surge of an appliance requires a meter with a peak hold (maximum) capability.

**Column L: Phantom Load**
Does this appliance consume power even when turned off? Home Power is ruthless with phantom loads! Our offices are totally controlled by plug strips. No phantom load is allowed to haunt the system. Column L will do three things. First, it reminds us to check each appliance while doing our load profile. Second, it reminds us later that this appliance is a phantom load and must be dealt with as such. Third, if for some reason this appliance is allowed to operate as a phantom load, we will remember that a separate entry must be made in the load table to reflect its energy usage (whenever the appliance is not in use).

**The Completed Load Survey**
You have combed your house testing loads. You have estimated future loads and maybe even made purchase decisions based on this load survey. But what does the table really tell you? The total at the bottom of column I.is most important. This number represents the average daily electricity that your household uses. This is also the amount of power that your RE system must generate daily.

Some days you do wash and some you don't. Some days you run a lot of power tools. Some days the sun shines and some it doesn't. There are inefficiencies in batteries and inverters. There are a lot of other variables involved in system design. However, average daily kWh is the basic need that must be met. All system design starts here!

Other information in this table (inverter priority wattage, max ac wattage, and max ac surge wattage) will become useful during system design. Do you install 220

## Examples

**Here are load tables for two example households. Both of these homes provide the same functionality, meeting the same needs and luxuries for their inhabitants. The only difference between these two homes is the efficiency of the electricity use.**

Home 1 represents the use of some inefficient appliances: a name brand refrigerator and incandescent lights are used. Also, the inhabitants of this home ignore the phantom loads, allowing them to run constantly. Notice that each phantom load has its own entry on the load table representing the power used by that appliance when turned off.

Home 1 uses an average of almost 7.4 kWh of electricity each day. At 65¢ per kWh this adds up to about $4.80 per day for electricity!

Home 2 represents a more efficient use of electricity: Compact fluorescent lights and an efficient refrigerator. Also, phantom loads are completely eliminated by the use of switched plug strips. These are the only differences between Home 1 and Home 2. However, Home 2 only uses an about 4 kWh per day of electricity. At 65¢ per kWh this is about $2.53 per day for electricity.

The $2.27 daily difference between Homes 1 and 2 is substantial. Over $828 dollars saved each year can easily pay for the expense of efficient appliances.

Remember, the accuracy of the final energy use estimate is only as accurate as the data within the load analysis table.

### Home 1 (inefficient)

| Appliance | Qty. | Volts | AC DC | P Y/N | Run Watts | Hours /Day | Days /Week | W-hours /Day | Percent of Total | Surge Watts | Ph-L Y/N |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Incandescent Lights | 4 | 117 | AC | Y | 60 | 5.0 | 7 | 1200.0 | 16.3% | 0 | N |
| Refrigerator RCA 16 cu. ft. | 1 | 12 | AC | Y | 141 | 10.0 | 7 | 1410.0 | 19.1% | 1300 | N |
| Blender | 1 | 117 | AC | N | 350 | 0.1 | 2 | 10.0 | 0.1% | 1050 | N |
| Microwave Oven | 1 | 117 | AC | N | 900 | 0.3 | 7 | 225.0 | 3.1% | 1200 | Y |
| Phantom Load-Microwave | 1 | 117 | AC | Y | 4 | 23.8 | 7 | 95.0 | 1.3% | 0 | |
| Food Processor | 1 | 117 | AC | N | 400 | 0.1 | 5 | 28.6 | 0.4% | 1200 | N |
| Espresso Maker | 1 | 117 | AC | N | 1350 | 0.1 | 7 | 135.0 | 1.8% | 1350 | N |
| Coffee Grinder | 1 | 117 | AC | N | 150 | 0.1 | 7 | 7.5 | 0.1% | 200 | N |
| 21" Color Television | 1 | 117 | AC | Y | 125 | 5.0 | 7 | 625.0 | 8.5% | 570 | Y |
| Ph/L-TV | 1 | 117 | AC | Y | 20 | 19.0 | 7 | 380.0 | 5.2% | 0 | |
| Video Cassette Recorder | 1 | 117 | AC | Y | 40 | 2.5 | 7 | 100.0 | 1.4% | 80 | Y |
| Ph/L-VCR | 1 | 117 | AC | Y | 15 | 21.5 | 7 | 322.5 | 4.4% | 0 | |
| Satellite TV System | 1 | 117 | AC | Y | 60 | 2.5 | 7 | 150.0 | 2.0% | 1600 | Y |
| Ph/L-Satellite Sys. | 1 | 117 | AC | Y | 22 | 21.5 | 7 | 473.0 | 6.4% | 0 | |
| Stereo System | 1 | 117 | AC | Y | 30 | 8.0 | 7 | 240.0 | 3.3% | 60 | Y |
| Ph/L-Stereo | 1 | 117 | AC | Y | 3 | 16.0 | 7 | 48.0 | 0.7% | 0 | |
| Computer | 1 | 117 | AC | Y | 45 | 6.0 | 3 | 115.7 | 1.6% | 135 | Y |
| Ph/L-Computer | 1 | 117 | AC | Y | 3 | 21.4 | 7 | 64.3 | 0.9% | 0 | |
| Computer Printer | 1 | 117 | AC | N | 120 | 0.3 | 3 | 12.9 | 0.2% | 360 | Y |
| Ph/L-Printer | 1 | 117 | AC | Y | 3 | 23.9 | 7 | 71.7 | 1.0% | 0 | |
| Power Tool | 1 | 117 | AC | N | 750 | 0.5 | 3 | 160.7 | 2.2% | 2250 | N |
| Radio Telephone (receive) | 1 | 12 | DC | N | 6 | 24.0 | 7 | 144.0 | 2.0% | 0 | N |
| Radio Telephone (transmit) | 1 | 12 | DC | N | 20 | 1.0 | 7 | 20.0 | 0.3% | 0 | N |
| Phone Answering Machine | 1 | 117 | AC | Y | 6 | 24.0 | 7 | 144.0 | 2.0% | 0 | N |
| Washing Machine | 1 | 117 | AC | N | 800 | 0.5 | 4 | 228.6 | 3.1% | 100 | Y |
| Ph/L-Washer Timer | 1 | 117 | AC | Y | 8 | 23.7 | 1 | 27.1 | 0.4% | 0 | |
| Clothes Dryer (motor only) | 1 | 117 | AC | N | 500 | 1.0 | 4 | 285.7 | 3.9% | 1500 | Y |
| Ph/L-Dryer Timer | 1 | 117 | AC | Y | 8 | 23.4 | 7 | 187.4 | 2.5% | 0 | |
| Sewing Machine | 1 | 117 | AC | N | 80 | 2.0 | 1 | 22.9 | 0.3% | 400 | N |
| Vacuum Cleaner | 1 | 117 | AC | N | 650 | 0.5 | 4 | 185.7 | 2.5% | 1950 | N |
| Hair Dryer | 1 | 117 | AC | N | 1000 | 0.2 | 7 | 200.0 | 2.7% | 1500 | N |
| Ni-Cd Battery Charger | 1 | 117 | AC | Y | 4 | 15.0 | 2 | 17.1 | 0.2% | 25 | Y |
| Ph/L-Batt Charger | 1 | 117 | AC | Y | 2 | 19.7 | 7 | 39.4 | 0.5% | 0 | |
| | | | | | | Total Daily Average Watt-hrs | | 7376.8 | | | |

Inverter Priority Wattage 599 Max ac Wattage 1350 Max. ac Surge Wattage 2250

### Home 2 (efficient)

| Appliance | Qty. | Volts | AC DC | P Y/N | Run Watts | Hours /Day | Days /Week | W-hours /Day | Percent of Total | Surge Watts | Ph-L Y/N |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Fluorescent Lights | 4 | 117 | AC | Y | 15 | 5.0 | 7 | 300.0 | 7.7% | 0 | N |
| Fridge Sun Frost 16 cu. ft. | 1 | 12 | DC | N | 48 | 11.3 | 7 | 540.0 | 13.9% | 1300 | N |
| Blender | 1 | 117 | DC | N | 350 | 0.1 | 2 | 10.0 | 0.3% | 1050 | N |
| Microwave Oven | 1 | 117 | AC | N | 900 | 0.3 | 7 | 225.0 | 5.8% | 1200 | Y |
| Food Processor | 1 | 117 | AC | N | 400 | 0.1 | 5 | 28.6 | 0.7% | 1200 | N |
| Espresso Maker | 1 | 117 | AC | N | 1350 | 0.1 | 7 | 135.0 | 3.5% | 1350 | N |
| Coffee Grinder | 1 | 117 | AC | N | 150 | 0.1 | 7 | 7.5 | 0.2% | 200 | N |
| 21" Color Television | 1 | 117 | AC | Y | 125 | 5.0 | 7 | 625.0 | 16.0% | 570 | Y |
| Video Cassette Recorder | 1 | 117 | AC | Y | 40 | 2.5 | 7 | 100.0 | 2.6% | 80 | Y |
| Satellite TV System | 1 | 117 | AC | Y | 60 | 2.5 | 7 | 150.0 | 3.8% | 1600 | Y |
| Stereo System | 1 | 117 | AC | Y | 30 | 8.0 | 7 | 240.0 | 6.2% | 60 | Y |
| Computer | 1 | 117 | AC | Y | 45 | 6.0 | 3 | 115.7 | 3.0% | 135 | Y |
| Computer Printer | 1 | 117 | AC | N | 120 | 0.3 | 3 | 12.9 | 0.3% | 360 | Y |
| Power Tool | 1 | 117 | AC | N | 750 | 0.5 | 3 | 160.7 | 4.1% | 2250 | N |
| Radio Telephone (receive) | 1 | 12 | DC | N | 6 | 24.0 | 7 | 144.0 | 3.7% | 0 | N |
| Radio Telephone (transmit) | 1 | 12 | DC | N | 20 | 1.0 | 7 | 20.0 | 0.5% | 0 | N |
| Phone Answering Machine | 1 | 117 | AC | Y | 6 | 24.0 | 7 | 144.0 | 3.7% | 0 | N |
| Washing Machine | 1 | 117 | AC | N | 800 | 0.5 | 4 | 228.6 | 5.9% | 100 | Y |
| Clothes Dryer (motor only) | 1 | 117 | AC | N | 500 | 1.0 | 4 | 285.7 | 7.3% | 1500 | Y |
| Sewing Machine | 1 | 117 | AC | N | 80 | 2.0 | 1 | 22.9 | 0.6% | 400 | N |
| Vacuum Cleaner | 1 | 117 | AC | N | 650 | 0.5 | 4 | 185.7 | 4.8% | 1950 | N |
| Hair Dryer | 1 | 117 | AC | N | 1000 | 0.2 | 7 | 200.0 | 5.1% | 1500 | N |
| Ni-Cd Battery Charger | 1 | 117 | AC | Y | 4 | 15.0 | 2 | 17.1 | 0.4% | 25 | Y |
| | | | | | | Total Daily Average Watt-hrs | | 3898.4 | | | |

Inverter Priority Wattage 325 Max. ac Wattage 1350 Max. ac Surge Wattage 2250

volts worth of inverters or do you run your single 220 vac load on your generator? Do you want an inverter that can run your ac well pump at the same time as the washing machine? What happens when someone turns the microwave oven on too? If you run the fridge and the well pump on DC, can you get away with a smaller inverter? These kinds of questions will come up during system design. Being able to refer back to a complete and detailed load profile will help with the answers.

**Access:**

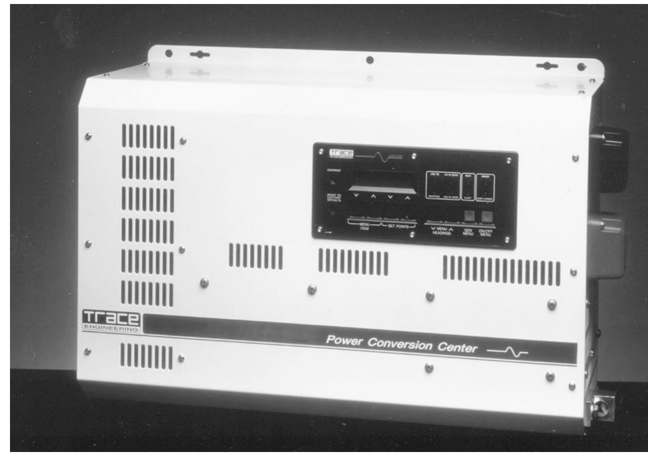
Ben Root is still trying to remember to turn off his stereo at night while writing and doing graphics for *Home Power* at Agate Flat.

c/o Home Power or E-Mail: ben.root@homepower.org

# Things that Work!

# Trace's SW2512 Inverter

Richard Perez




The Trace sine wave inverters are the most versatile and robust that we've tested. They offer high power, high efficiency, and interface easily with power sources and loads. Here's the results of a year long test on Trace's smallest sine wave inverter, the 12 Volt to 117 vac SW2512.

**Shipping Container and Documentation**

The Trace SW2512 inverter arrived in fine shape via UPS shipping and a six mile bumpy ride in the back of a 4WD pickup truck. The carton and its foam containment allow shipping virtually anywhere without damage. Which is good because the shipping weight of this inverter is 96 pounds (44 kg).

The documentation supplied is outstanding. Which is also a good thing because the days when the only control on an inverter was an "on/off" switch are over. The 90+ page owner's manual covers everything from setup to operation. It is generic and covers all Trace sine wave inverters, not just the SW2512, possible since all the SW series inverters use the same microprocessor control. If you know how to program any Trace sine wave, then you know how to program them all.

**SW2512 Specifications**

This is a big inverter—2,500 watts output continuous at 117 vac. Input is 12 VDC nominal, but the unit functions from 11.8 to 16.5 VDC. It is also big physically—15 inches (38 cm) high, by 22.5 inches (57 cm) wide, by 9 inches (40 cm) deep.

The SW2512 functions both as an inverter and a battery charger capable of delivering 150 Amperes DC. The charger is equipped with the latest three stage recharge technique to fully recharge lead acid cells without stressing them out. The charger is programmable so it will not overload small 120 vac sources like low power generators.

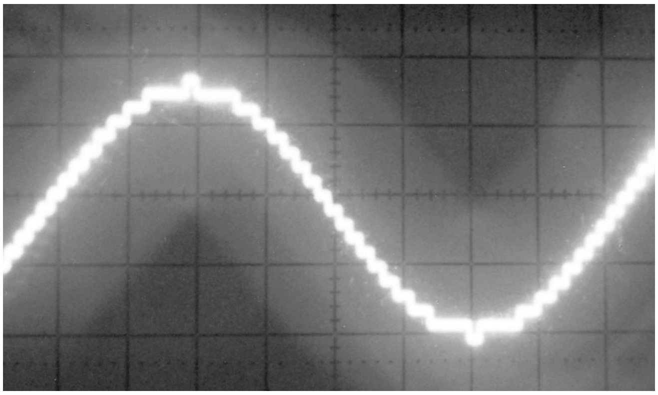
The SW2512 will also interface with the utility grid to sell your excess renewable energy. This is revolutionary! Those who are grid connected can efficiently contribute their excess solar, wind, or hydro energy back to the gird and also recharge their battery from the grid when the RE sources are not up to consumption.

The list of things which this inverter will do is too long to go into here. It is unlikely that a single system will ever use all these functions, but it's nice to know that whatever you may need is already built-in. For example, the Trace SW2512 can start your 120 vac engine/generator, automatically recharge the battery, and then shut the generator off. And, if your RE sources are going strong and the battery is fully recharged—no problem, the Trace will automatically divert excess power into a 120 vac load such as a water or space heater. These are just a sample of the power built into the microprocessor in the Trace SW inverters. The Trace SW2512 we tested used the latest rev. 4 software. Yes, inverters now come with software built in. This allows considerable fine tuning of operation without rebuilding the inverter's hardware. If you are a Trace SW series owner using an older inverter with the

older software, then call Trace, or your installing dealer, and see about a software upgrade.

The SW2512 inverter's output is a stepped sine wave with between 34 and 52 steps for each alternating current cycle (see photo). Total harmonic distortion (THD) of the output power is rated at 3 to 5%. This means that the SW2512 makes electric power which is, on average, far purer than the utility grid can deliver. The SW2512's sine wave is clean enough to operate virtually any appliance without the problems associated with the older, modified sine wave inverters. Perhaps a word on the difference between modified and sine wave power is in order.

The reason to use a sine wave inverter is simple—sine wave electricity is what every 117 vac appliance was designed to consume. The mod sine wave inverters will power many appliances, but they certainly won't power them all. This list of mod sine incompatible appliances is wide and long—everything from rechargers for cordless drills to laser printers. Even appliances which digest mod sine power will work better if fed pure sine wave power. Our 120 vac well pump pumps about 30% more water per minute with sine wave electricity over being fed mod sine power. Most electric motors will run faster and cooler (which means more efficiency and longer motor life) when fed sine wave power. Computer power supplies run quieter and cooler. TV and radio devices run quieter. This is why the purity of the inverter's power production (measured as THD) is so important. Most mod sine wave inverters make power with 25 to 40% THD. Sine wave inverters make power with between 1 and 5% THD. The Trace SW2512 makes power that is pure enough to be approved for utility intertie by Pacific Gas & Electric, California's mega-utility and the largest investor owned utility in the world.



Above: a photo of the Trace's 117 vac waveform taken from our oscilloscope. Note the stepped nature of the synthesized sine waveform.

**Installing the SW2512**
We installed the Trace SW2512 on 1 March 1996, and have had it running continuously since then. It is installed in our main system here on Agate Flat. We used 4/0 copper cables to tie it to the battery bus bars. An Ananda "Big Switch" with 400 Ampere Class T fuse to protects the inverter against overcurrent. We gave the SW2512 its own 500 Ampere, 50 mV. shunt for our instrumentation.

**Trace SW 2512 INVERTER TEST - 24 February 1997**

| *INPUT DATA ON THE 12 VDC SIDE* | | | *OUTPUT DATA ON THE 120 VAC SIDE* | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| *Battery Volts* | *Amps DC* | *Watts DC* | *Vrms OUT* | *Amps ac* | *Vpp+ OUT* | *Vpp- OUT* | *Watts OUT* | *Eff. %* | *Appliance Notes* |
| 16.10 | 3.1 | 50 | 119.5 | 0.20 | 168.8 | -168.8 | 23 | 47% | Incandescent Lights |
| 16.08 | 5.7 | 92 | 119.0 | 0.56 | 167.6 | -167.2 | 67 | 73% | Incandescent Lights |
| 16.06 | 7.7 | 124 | 118.5 | 0.84 | 166.8 | -166.8 | 99 | 80% | Incandescent Lights |
| 16.12 | 9.2 | 148 | 118.5 | 1.03 | 167.2 | -167.2 | 122 | 83% | Incandescent Lights |
| 16.04 | 12.2 | 196 | 118.6 | 1.39 | 165.2 | -164.8 | 165 | 84% | Incandescent Lights |
| 16.00 | 13.7 | 219 | 118.1 | 1.58 | 164.8 | -164.8 | 187 | 85% | Incandescent Lights |
| 16.00 | 17.5 | 280 | 117.8 | 2.08 | 164.0 | -163.6 | 245 | 87% | Incandescent Lights |
| 15.04 | 98.0 | 1474 | 117.4 | 11.40 | 171.6 | -170.8 | 1338 | 91% | Water Heater |
| 14.90 | 113.0 | 1684 | 118.6 | 12.50 | 167.6 | -167.6 | 1483 | 88% | Space Heater |
| 14.10 | 201.0 | 2834 | 117.4 | 18.90 | 162.0 | -160.8 | 2219 | 78% | Both Heaters |
| 13.50 | 272.0 | 3672 | 117.0 | 22.70 | 161.6 | -160.4 | 2656 | 72% | Both Heaters (Hi) |
| 15.20 | 308.0 | 4682 | 116.5 | 26.20 | 158.0 | -158.8 | 3052 | 65% | Both Heaters & Toaster |

One note on installing the SW series Trace sine wave inverters—get help! It takes at least three people to bolt a SW series inverter to the wall. Two to hold the inverter and one to run the wrenches. This inverter is heavy. Trace recommends using 1/4 inch diameter bolts to mount the inverter.

**Performance**

The performance of the Trace SW2512 meets its maker's specifications (see table). Power stability, volts rms, volts peak, and efficiency are all on spec. We even overloaded the SW2512 for a while (see last entry on the table). In terms of real world service, we've been using the SW2512 for the last year. It has worked flawlessly. We primarily use it for our larger 120 vac loads. The SW2512 powers our microwave oven, espresso maker, toaster, coffee grinder, food processor, deep well pump, myriad power tools, laser printer, swamp cooler, and more, just like downtown. In addition to the well pump mentioned earlier, our swamp cooler really loves sine wave power. It has a "low" speed fan setting. Using mod sine wave, the fan on the low speed setting would just sit there and buzz—no air out. With the sine wave inverter, the low speed fan works and is what we use most of the time. Best of all—no buzzzz.

What surprised me in our application was the powerful battery charger. We set it to maximum (150 Amperes DC) and it actually delivered the full 150 Amperes when powered by our Honda 6.5 kW engine/generator. Most chargers built into inverters only run at about 60% of rated capacity when powered by engine/generators. High power, coupled with the three stage charge regime, will make better use of generator power, reduce fuel consumption, and lengthen battery life. The charger has wide voltage limits, high enough to recharge our NiCd battery. The Trace SW series inverters have the best battery chargers I have ever seen in an inverter.

The SW2512 is the most efficient 12 VDC sine wave inverter we have tested at *Home Power*. Mod sine inverters, however, are more efficient than sine wave models. I started thinking about the 30% more water I was getting from our deep well pump and the low speed that actually worked on the swamp cooler. I decided to enlarge the circle around which efficiency was calculated to include the performance of the appliance. If you are using the electricity for anything other than resistive loads (heaters and incandescent lights), then the sine wave is as efficient, or more efficient, than the mod sine wave. This efficiency calculation includes the appliance's performance (i.e. more water pumped or more air moved). What we haven't yet determined is appliance longevity. The fact that most appliances run cooler on sine wave power makes me believe that they will last longer. Time will tell….

Can I imagine anything better than this inverter? You bet! I spend most of my working life dealing with computers. Being confronted with the possibilities and complexities of Trace's microprocessor, I am frustrated at only having eight push buttons, a two line alpha numeric LCD display, and eight LED indicators to program/operate the inverter. An energy program of the intensity of Trace's deserves better data output and better user input. Does this mean I could not figure out how to program the inverter? No, but I had to read the manual thoroughly and pay attention. I'd like this entire process simpler and more straightforward. In order to communicate easily with a microprocessor system, you need more than a few lines of text and eight keys. I hear Trace is already at work on this problem.

**Conclusions**

The Trace SW2512 inverter is great for medium-sized home systems. It interfaces RE sources, generators, batteries, and the utility grid into seamless, sine wave electricity. It costs US$2,585 and is worth the money.

**Access**

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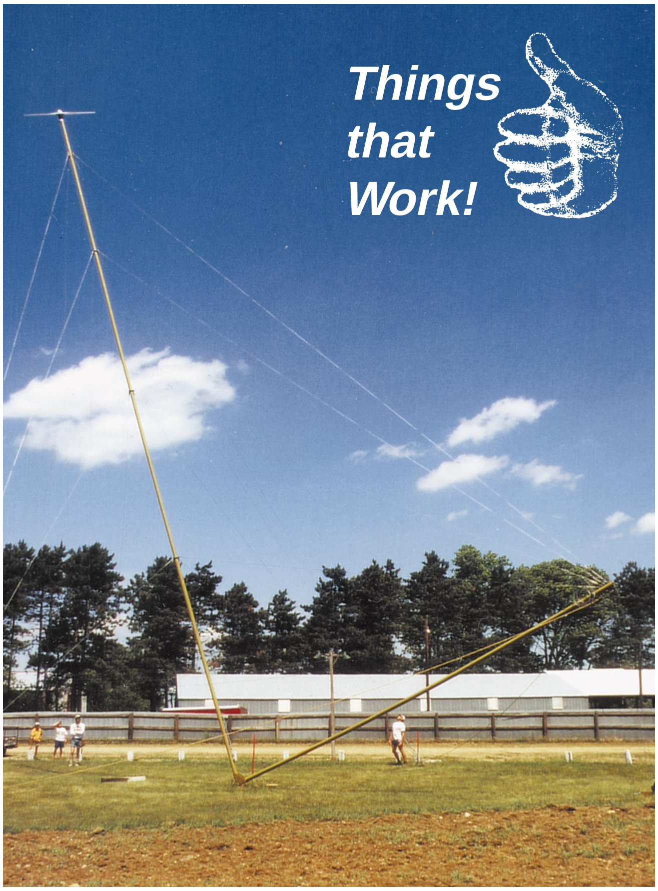
# Lake Michigan Wind & Sun's 80 Foot, Tilt-up, Wind Generator Tower Kit

Bob-O Schultze with Joe Schwartz






Up she goes...without a hitch.

Like a man singing in his own bathroom, I am fearless when it comes to designing and building my own RE systems. Four years ago I built my own 63 foot tilt-up wind generator tower. It was a great learning experience. I learned that I didn't want to build a second one! Now I don't have to. Lake Michigan Wind & Sun has come up with a strong, reliable, good looking, tower kit that takes nearly all the engineering and design guesswork out of putting up your favorite wind generator.

### The Tilt-Up Wind Tower

No doubt the main reason that wind generation is largely underutilized is the problem of getting and keeping the genny up in its element—clean, unturbulent air. Even for wind enthusiasts with the site, means, and desire to fly a genny, the tower often presents an insurmountable obstacle. Wind towers are expensive, difficult to erect, and make the generator hard to maintain. While climbing a tower is both exciting and romantic (did I mention scary?), there's no better way to install and maintain a wind machine than having it on the ground. This is true as well for the tower itself, whether for periodic inspection, repainting, or tightening and checking the rigging.

For those still unfamiliar with tilt-up towers, here's a quick overview. The tower consists of 20 foot sections of four or five inch diameter pipe joined by couplers. A gin pole, roughly one-third the tower's height, is connected to the tower base at slightly less than 90 degrees. The gin pole provides leverage during tower raising or lowering. The tower is stabilized by multiple guy wires which, on a properly installed tower, remain in place and under tension during tower raising and lowering. Using this system, the wind generator is mounted and the wires run while the tower is still on the ground. Tilt-up towers can then be quickly and safely raised or lowered by two people with a 4x4 vehicle, small tractor, or a winch. For our money, the tilt-up tower is the way to go for a maintainable, affordable residential or light industrial wind generator installation.

### The Kit Concept

Shipping heavy, bulky metal tower sections is very expensive and doesn't make much sense from an energy consumption perspective. LMW&S provides easily shippable slip couplings which fit into locally purchased steel tubing, costing between $3 and $6 per foot, to make up the tower and the gin pole. The couplers also provide anchor points for the guy wires. The kit includes the pivot plates, tower base anchor and the guy anchors. Drilling templates are provided for connecting the pivot plates to the tower and gin pole and to mount the wind genny to the top tower section. There is no welding required. A comprehensive instruction manual guides you step by step from setting and aligning the anchors thru proper tightening of the guy cables.

The kits come in two stages. The complete kit incudes anchors, all fabricated parts, guy cables, all assembly hardware, and the all important instruction manual. You provide the tubing, ground rods, and the concrete and rebar for the anchors.

The basic kit has all the fabricated parts including the anchors and the manual. You provide the guy cables, thimbles, cable clips, nuts, bolts, and washers.

There are two optional packages. A turnbuckle kit makes the initial straightening and tightening of the guy wires easier and faster. The lift package provides the multisheeve pulleys, lift cable, and hardware for raising and lowering the tower. We tested the complete kit with the lift package. Since we are experienced with cables and have cable grips, we passed on the turnbuckles.

**Layout**

You know the old adage that says, “When all else fails, read the directions”? Don’t do this. Setting up a well designed wind tower is a complex and potentially dangerous operation. Remember that your layout and anchors are literally “set in stone.” If you follow the directions carefully you'll be rewarded by a smooth, safe tower raising. If you don’t, you’re in hell.

The most important part of layout is setting the anchors level. A properly laid out tilt-up works great, a poorly laid out one doesn’t. You’ll need a sight level (aka Abney or farmer’s level), water level, or transit. Ideally, ALL the anchors and the center tower support should be level to each other. At a minimum, the center and two side anchors MUST be level. If they aren’t, the tower will bind and pull to the low side during raising and lowering. That means slacking or tightening the side tower guys while the tower is going up or down. This is dangerous and the possibility of something catastrophic happening shoots way up. It’s also important to double check that you’ve got enough room for the total length of the tower and genny to lay down and for the lifting vehicle to back up far enough to fully raise the tower.

**Set-up**

Lake MIchigan Wind and Sun manufactures tilt-up tower kits from 40 feet up to 120 feet in height for wind machines up to 4500 watts. Tower kit prices vary from $995 to $3,895 depending on genny size, complete or basic kit, and tower height. Our site required an 80 foot tower to get our 1,500 watt Whisper wind genny a good distance above the tree tops. We ordered six 20 foot lengths of four inch steel tubing, enough to give us 80 feet for the tower and 32 feet for the gin pole. Our steel supplier delivered them to the job site, saving us from having to rent a trailer. If your site isn’t too far out in the boonies, most steel suppliers will do this for free or a small fee. We joined the tubes together by the kit couplers provided and connected the guy wires. The couplers are cleanly welded and usually slide right into the pipe sections. If not, a block of wood and a mallet will do the trick. A tech note: depending on your steel supplier, the tubes may come in somewhat random lengths. Make sure you ask for tubes that are 20 foot or better in length. You can always trim off any extra. The cables are all pre-cut based on 20 foot tubes. An inch or so one way or the other isn’t going to matter much, but if each tube runs long, you could run short of guy cables for the upper sections.

The base of the tower is connected to the center anchor with two 3/8 inch steel pivot plates. When laying out the guy wires, make sure to unroll the guy wire loops as if you were rolling a tire. Grabbing one end and tugging doesn’t work! This approach will leave you with a kinked up, tangled up mess o’ guy wires along with a headache to boot. All the guy wires are laid out, connected to the lower anchors and couplers, and the cable clamps hand tensioned prior to raising. The lift cable and multiple pulley arrangement is designed for a given tower height and weight. If you provide these parts yourself, make sure you know what you’re doing.

**Operation**

We were fortunate to have a small Kubota tractor available on site. It had the power and the low gearing to allow raising the tower very slowly and safely. We’d recommend at least a four wheel drive pickup with a low range for lifting the tower. For a big tower or heavy wind machine, you might want to put some weight in the bed and pull in reverse to insure good traction and good driver/groundsman eye contact. With hard hats on all workers and onlookers, we took up tension on the lift cable and made a last check on all the guy cables and rigging to make sure nothing was fouled. Lift slowly and steadily with at least one person keeping a constant eye on all the guys and the tower for any sign of binding or cable fouling. As the tower nearly reaches vertical, the ground person will want to hold back some on the uppermost rear guy cable to let the tower come to its final position gently without slamming down and straining the rear guys. Secure the gin pole to the front guy with a jaw to jaw turnbuckle. Starting with the lowest guys, tighten opposing cables to the specs provided in the manual. Use a four foot level to plumb the first tower section and eyeball thereafter. Safety wire the anchor plates to the anchors, attach your grounding rods and you’re done!

**Warts**

Not very many. We found that the templates for drilling the pivot plate holes and generator mounting holes were off just a skosh and some reaming with a drill bit was necessary. To be fair, I’d have to blame the

variations of tube wall thickness rather than any inaccuracy of the template. Tubing comes in many different varieties: Hot rolled, cold rolled, welded, seamless, and in different gauges or thicknesses. Also, since all of our drilling was done by hand on site without the aid of a drill press or table, there was probably a bit of inaccuracy in our hole placement.

The wires running from the wind genny to the controls exit from the bottom of the tower. There isn't a good way to make the transition from the tower to your buried wire run. We made the transition with non-metallic flexible conduit (Carflex) but noticed some pinching when we lowered the tower. If there was more space between the tower base and the top of the center anchor this problem could be eliminated.

**Conclusions**

For better or for worse, the climb up the old wind genny tower is about to become a thing of the past. Lake Michigan Wind and Sun's tilt up tower makes for a fast and, more importantly, safe install. Way to go LMW&S!

**Access**

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# One's Faster, the Other's Quicker


**Shari Prange**



Above: The "Spirit of San Antonio II" streamliner on the Bonneville Salt Flats.
Photo by Lloyd Healey

Brought down to its purest element, racing is speed. There are two forms of racing that demonstrate this most clearly: land speed record trials and drag racing.

Both types of events run in a straight line, and are over quickly. Each car runs alone on its track, with no traffic to interfere. Beyond that, however, they are very different events.

### Land Speed Record Trial

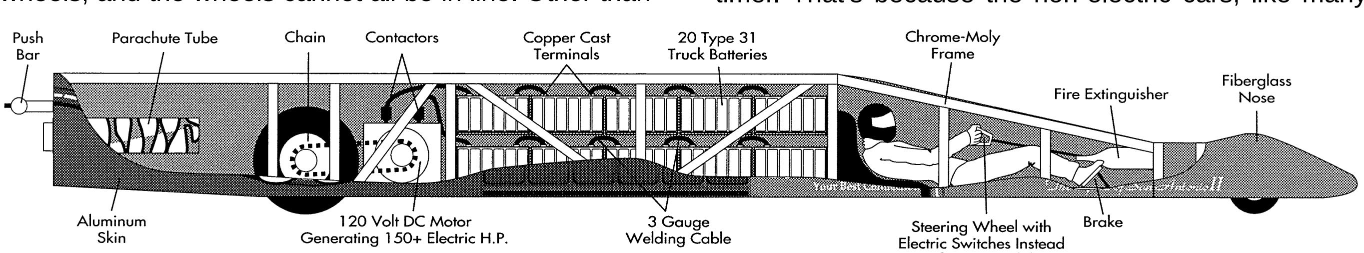
This event measures the top speed a vehicle can achieve under optimum conditions. There are very few restrictions on the cars. They must have at least four wheels, and the wheels cannot all be in line. Other than that and some safety equipment, the design is wide open.

The cars come in two types, streamliners and lakesters. The streamliners have their wheels fully enclosed by the body. The lakesters are "open-wheel" vehicles. They are divided into classes by weight.

These cars require a very long, flat, and smooth course, so the events are usually run on dry lake beds or airstrips. The most famous course is on the Bonneville Salt Flats in Utah.

### Racing The Clock

Each car runs alone against the clock. It takes a long running start toward the first timer to build up speed. Actually, for many cars it's more of a pushing start, since another vehicle pushes it, and peels off before the timer. That's because the non-electric cars, like many



high performance racers, have no onboard starters. In EVs, the gearing is often so high that the car simply isn't capable of low speed, so the car is pushed up to 50 mph or so.

Streamliners take two miles just building up speed to the starting clock. Then they run for three miles, with a timing clock at the end of each mile. Traditionally, a land speed record run took the best average speed over a one-mile segment of the course. Then the car had to turn around and run the same course in the opposite direction within one hour. The speeds from the two runs were averaged together individually for each one mile section of the track. The best two-run average for a one-mile section—"the same piece of ground"—was the official time.

Other records were also recorded for the fastest "flying mile" in one direction, and for the fastest top speed "out the back door" at the last clock.

It can be tricky to try to compare records. Conditions vary from track to track and from day to day. Also, due to the deteriorating condition of the salt flats, it is no longer possible to do a second run immediately in the opposite direction. Instead, the car must do a second run in the same direction at the next opportunity, which may be several days later. However, only one hour can be spent refueling and preparing the car for the second run. The car is in impound for the rest of the time between runs.

Above: Ed Rannberg's streamliner, the "Lightning Rod."
Photo courtesy of Ed Rannberg

It costs several thousand dollars to get a speed run officially certified by the FIA (Federation Internationale de l'Automobile). The "Spirit of San Antonio II," driven by Lloyd Healey, was the first EV to exceed 200 mph in the fall of 1996, and Lloyd has broken several other records without FIA certification because of the expense involved.

**Torpedo On Wheels**

These cars have a distinctive long, low, bullet shape, which minimizes frontal area and aerodynamic drag. They are typically less than two feet high or wide, but

Below: Ed Rannberg and his electric dragbike, the "KawaShocki." Photo courtesy of Ed Rannberg

more than twenty feet long. Claustrophobes need not apply.

Despite their high speeds, they use DC motors much like the ones in street conversions, although system voltage will approach 300 Volts. Old EV hand Ed Rannberg has experimented with various configurations. He learned that it didn't work to run two motors in parallel: one motor hogged all the amps until it self-destructed, while the other merely went along for the ride. He now runs two motors in series, which divides the voltage between them instead of trying to divide the amperage.

Due to the high current draw, he uses three controllers in parallel, with a single brain controlling all three. His car is powered by 288 Volts of Hawker Genesis batteries, wired in series / parallel. These are sealed 12 Volt 26 Amp-hr. batteries normally produced for emergency standby power.

Ed's design for his "Lightning Rod" has him sitting at the very back of the vehicle, behind the rear axle. In contrast, Lloyd Healey sits in the nose of his car. Ed uses a belt drive, and Lloyd uses a chain drive. In addition, Lloyd has configured his batteries in modules with contactors between them, so he can add and remove groups of batteries to qualify for different weight categories.

**Okay, Now Stop**

Although these cars are equipped with carbon fiber disks, you simply can't stop a 200 mph missile with ordinary brakes. Instead, a parachute in the tail of the car is deployed to slow it to a stop. Needless to say, there is no such thing as "stop-and-go" driving in one of these cars. This can add a new level of excitement. Lloyd has had his parachute open prematurely, while Ed has had his fail to open. Both situations ended without disaster, luckily.

Since these cars have no suspension, even small bumps or cracks in the salt surface are very apparent, especially at 200 mph. As Ed says, there's no traffic and no steering to do, so you have a lot of time to wonder, "Why am I doing this?"

**Speed Costs Money**

It's hard to accurately price a car like this, since much of the labor and parts have been donated. Lloyd figures he has about $40,000 in his car. He's very grateful for help from his co-builder Mike Meeks, and sponsorship from Powertron Batteries, Quick Cable, and Kilovac contactors. Ed estimates the "Lightning Rod" at $100,000, with assistance from manufacturers such as Curtis/PMC, Advanced DC Motors, and Eric Luebben at Cybortronics.

Both Ed and Lloyd have broken 200 mph top speed, but neither yet qualifies for the 200 Club. To do that, you must average 200 mph over two runs.

Lloyd is passing the speed need to his kids. First his daughter Megan and now his son John have held the position of youngest driver on the salt flats at 8 years old, although their cars were a little slower than dad's.

Lloyd's next project is an electric "Baby Grand" drag racer for Phoenix. This is an exact 2/3 scale replica of a stock car.

**Wanna Drag?**

Which brings us to the other kind of speed racing, the all American drag race. While streamliners compete for ultimate top speed, drag cars compete for acceleration from a standing start over a quarter mile. The whole race lasts about ten seconds.

Every weekend, there are friendly drag races at numerous sites around the country. Veteran Phoenix EV racer Jesse James characterized the APS Electrics drags as "laid back and a lot of fun."

Drag racers can be stock cars, go-karts, or dedicated "rails." The most common kind of drag racing is bracket racing. Cars are paired up randomly, then handicapped to match speeds as closely as possible. A ten-second car will get the green light three seconds sooner than a seven-second car. After that, it depends on the reaction time of the driver. They run two at a time in side-by-side lanes in elimination rounds. The winner of each pair races the next car until it is eliminated. At the end, one winner remains.

Because the cars are paired on a purely random basis, odd pairings are possible. A dedicated drag rail that could never drive on the street may be competing against a souped up stock car.

This also makes it possible for EVs to compete against conventional cars. Michael Beebe of Ohio, has raced his electric Honda-based kit car at several events, and has had the distinction of beating a Cobra, much to the chagrin of the assembled Cobra owners.

Dennis Berube of Arizona, is a life-long drag racer who now races purely electric. He drives a dedicated drag rail, the "Current Eliminator II," that can reach 117 mph, and turns a quarter mile in 11.43 seconds. In those few seconds, he uses up 60% of his usable charge. The car runs on 312 Volts of Hawker Genesis batteries and a series DC motor with a semi-automatic transmission that sequences through four gears in those eleven seconds. He races several dozen times a year against conventional cars at National Hot Rod Association (NHRA) events, and his times are competitive with the gas cars.

### Laying Rubber

Before a drag race, drivers create lots of noise and clouds of smoke spinning their wheels. This is not just macho posturing. They are "burning in" their tires, getting the rubber hot and sticky. This is necessary to make the tires grip the track.

The driving technique for an EV drag racer is pretty much the same as for a conventional drag car. Jesse James found he got a quicker start if he revved up the motor first, then feathered in the clutch. Even in a stock car with a standard transmission, he used three gears in the quarter mile.

Dennis, who has raced both conventional and electrics, said that the EVs are quicker off the line. This is due to the enormous torque that an electric motor can provide from a standstill. "The most important aspect of a drag car is consistency," Dennis says. This is crucial when the car must survive so many matches, which are often decided by tiny fractions of a second.

Ed Rannberg also drag races on an electric motorcycle he calls the "KawaShocki." The bike runs on 192 Volts of Hawker Genesis batteries. It can turn a quarter mile in 11.5 seconds and reach 110 mph. Ed races against gas drag bikes, and delights in beating them.

One problem electric dragsters face in bracket racing is the lack of recharge time. Jesse found at the APS Electrics that many cars did not have time to get a full charge between afternoon practice and the evening drags. A slightly less than full charge made a significant difference in performance. Ed's drag bike is limited to demonstration events because he cannot recharge fast enough for the next elimination round. Dennis has a massive custom charging unit that recharges his rail in fourteen minutes.

### Show Me The Money

With bracket racing, a drag car can be built on a shoestring from a stock car or can run into six digits for a tricked out rail. The average is probably in the $40,000 range.

On any weekend at a local dragstrip, a good car can take home a few hundred dollars competing against a couple dozen cars. At the bigger events, there may be a hundred cars and a potential of a couple thousand dollars in prize money. Except at the top ranks, drag racing is done purely for love, because you won't get rich at it.

Both streamliners and dragsters are about speed. For streamliners the top speed is what counts. For dragsters, it's how quickly you get there. However you define "speed," there are EVs out there pursuing it.

### Typical Specifications

**Land Speed Record**

| | |
|---|---|
| *Car Type* | Purpose Built |
| *Streamliner* | Closed Wheel |
| *Lakester* | Open Wheel |
| *Design Constraints* | Open Design (4 Wheels Not Inline) |
| *Weight* | 800 - 1350 lbs. (Without Batteries) |
| *Voltage* | 300 volts |
| *Racing Speed* | 200 mph |
| *Course Type* | Strip (Dry Lake Beds & Airstrips) |
| *Course Length* | 5 miles |
| *Start Type* | Flying |
| *Duration* | Sprint (One Minute) |
| *Field Size on Course* | One Car |
| *Winning Criteria* | Speed (Average For One Mile) |
| *Sanctioning Body* | Federation Internationale de l'Automobile & others |

**Drag Racer**

| | |
|---|---|
| *Car Type* | Stock or Purpose Built |
| | Open Wheel or Closed Wheel |
| *Design Constraints* | Open Design |
| *Weight* | 2500 lbs. Stock<br>1200 lbs. Purpose Built |
| *Voltage* | 300 volts |
| *Racing Speed* | 100+ mph |
| *Course Type* | Strip |
| *Course Length* | 1/4 Mile |
| *Start Type* | Standing |
| *Duration* | Sprint (Under 15 seconds) |
| *Field Size on Course* | Two Cars (Separate Lanes) |
| *Winning Criteria* | Speed (First Across Finish) |
| *Sanctioning Body* | National Hot Rod Association & others |

**Access**

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# EV Tech Talk

**Mike Brown**



### "I live in the country and drive 60 miles to town in a 4WD pickup. Is it possible for me to use an electric vehicle?"

This kind of question involving electric vehicles in extreme duty situations comes up frequently. The short answer is, "Probably not." However the question deserves a more detailed answer than that, breaking the question down into some separate parts.

First, the 60 mile trip into town and another 60 mile trip home gives a 120 mile round trip. With the usable range of 60 to 80 miles on flat dry pavement in warm weather, the average conversion EV would get you to town but would need a battery charge to get you home. Do you have 8 to 12 hours to spend in town and a place to charge?

The words "I live in the country and drive a 4WD pickup truck" are our second clue to a non-EV-friendly environment. Unless it is being used as a fashion statement (as many are), the 4WD pickup indicates that the country roads it is driven on are probably dirt, and their condition may change depending on seasons. The increased drive train losses and tire rolling resistance of a 4WD vehicle would cut the range down to 50 to 70 miles. The dirt country road would, even if dry, subtract another 5 to 10 miles of range.

If you throw in mud, snow, and hills for worst case conditions, a range of 20 to 30 miles might be the best you could expect. If you had the air temperatures associated with snow, the range would be further reduced because batteries lose 10% of their capacity for every 20° drop in air temperature. Since, under extreme weather conditions, getting to your destination could be a matter of life or death there are too many variables to make this application practical for an EV.

Even if the distances are shorter and road conditions more favorable but you live off grid, the matter of charging must be dealt with. Will your power system be able to provide 20 amps at 220 volts for 8 hours, or 20 amps at 110 volts for 12 hours? The expense of upgrading your power system to support an EV would probably be more than the fuel and operating cost savings.

My answer to this question is, "Until we get big improvements in energy storage—batteries, fuel cells, etc.—and in battery charging, an EV is not a practical means of transportation for back country use. Until these improvements come, the best thing for your safety, budget, and the environment is to buy the most fuel efficient vehicle that suits your needs and keep it well maintained.

### "What is the best car to convert into an electric vehicle?"

Let's change the question around a little and look at some of the many answers to the new question.

The question to ask is, "What kind of a vehicle do I need for my daily use, and could it be an EV?" Then start asking yourself some hard questions. Do I drive 20 miles a day or 200 miles? Is my commute a short, fast sprint on freeways and expressways, or long slow slogs on surface streets? Do I drive by myself most of the time or do I frequently have to haul a boys' soccer team? Do I own or have access to a gas car for occasional long trips? Does my house, condo, or apartment have an accessible source of electricity at the right amperage to charge an EV? If not, can such a source be installed safely, easily, and economically? If my daily commute round trip is close to or exceeds the EV's range, can I charge at work?

If a vehicle with a 60 to 80 mile range, a top speed of 65 to 80 mph, and a need for its own dedicated refueling facility (possibly one at each end of your commute) will honestly fit your needs, then we can ask which is the best car to convert.

The best base cars to convert are the subcompact cars such as the VW Rabbit, Honda Civic, Ford Escort, etc. Small trucks such as those made by Nissan, Toyota, and Mazda, as well as the Ford Ranger and Chevy S-10 are suitable for conversion.

Smaller cars such as the VW Bug, Geo Metro, and most two-seat sports cars are convertible, but their size presents challenges in finding room for the required number of batteries. EVs are mission-specific vehicles, so a careful analysis of your mission for the car will help you pick the car to convert. The three key factors to identify are cargo or people capacity, battery capacity required for the daily mission, and the terrain and traffic conditions of the trip itself.

If your round trip mileage is close to 60 miles, go for a car that has space enough for 16 to 20 of the high capacity 6 Volt batteries. The same goes for a route with hilly terrain, slow bumper-to-bumper traffic, or a four person carpool.

However if you are usually by yourself with a short commute and always wanted a sports car, a two seater with smaller, lighter, but lower capacity 12 Volt batteries would fit your needs.

Need to haul material for weekend projects or make short local deliveries for your business? One of the small trucks mentioned above might be your best choice.

As you can see there are many factors in the choice of a car to convert. For a more detailed discussion of this topic see *HP* #31, page 32. If you still have questions write, phone, or fax me and we'll talk about it.

### "The lead-acid batteries in my EV are showing their age—less range and slower top speed. I've heard of EDTA treatment, electronic desulfators, and the Bat Juice additive. Which one works best?"

The answer to this question lies in how the batteries have been treated during their life. If they have been discharged and charged regularly and the water has been kept at the proper level, but they have been in service for 3 1/2 to 4 years, they are probably just worn out. This is caused by the active material on the plates getting thinner as the batteries are used, and no treatment or device will help at this point. You should decide if their condition affects the usefulness of the EV and if so, start shopping for a new pack.

However, if the car has been left with the batteries discharged for a long period of time, or a charged pack has been allowed to sit until the batteries' cell voltage has fallen below 1.955 Volts through self-discharge, or the water level has fallen below the top of the plates, sulfation has probably occurred. For a good explanation of the sulfation process see *HP* #29, page 44.

In most of my experience with EV batteries, they failed after a long hard life. I have no personal experience with restoring sulfated batteries, so I am relying on others for these answers.

The *Home Power* crew has done and documented the EDTA treatment (see *HP* #20, page 36 and *HP* #21, page 36) and has feedback from hundreds of readers who have tried EDTA. It seems to be successful in most cases. If you are sure that sulfation is your problem, this is the best documented treatment of the three you listed.

The electronic desulfators seem to be geared more to prevention than cure. My battery guru said they have a place in preventing sulfation in batteries that sit for long periods of time between uses, such as the batteries in an RV that only gets used twice a year. A drawback is the necessity for more than one unit per battery pack for a high voltage EV system. The expense and complicated wiring seems prohibitive to me.

The pros and cons of the B.A.T. battery additive, or BAT Juice, have produced some of the most intense controversy in the EV world I have ever seen. What I haven't seen is any documentation from a customer who wasn't a sales rep for the company. Another minus is a reported $300 cost for enough to treat an EV battery pack. Also, like the electronic desulfators, the BAT Juice is intended to prevent sulfation in a healthy pack, not cure it in a sick one.

Again, as I have no personal experience on either the electronic devices or the BAT Juice, I would welcome any feedback (as long as it isn't a sales pitch). If the information passes muster, I will publish it.

If I had a battery pack that I knew was sulfated, based on the evidence I have seen so far, I would go with the EDTA.

**Access**

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# Batteries

## What We Know About Them
## How to Use Them

John Wiles



Batteries represent a significant initial and continuing cost in a renewable energy (RE) system. The RE owner is sometimes in a quandary when it comes to taking care of the batteries and getting the most bang (amp-hour) for the buck.

There is much information available on battery usage, but this information represents battery use in uninteruptable power systems, stationary float applications, and other systems not related to renewable energy. There are only a few full-fledged, well-documented, RE battery test programs that have been reported in the technical literature. Few PV battery systems have been accurately monitored using data acquisition systems. Nearly every battery "expert" will have different ideas. In most cases, these ideas come from observing different systems in different modes of operation, few of them relate to the small-to-medium sized renewable energy system using flooded lead-acid batteries. The ideas presented are not necessarily mine and have been gathered from a number of sources.

**Battery Facts**

Batteries can be charged and discharged over a wide range of voltages, currents, and temperatures. However, maximum capacity, cycle life, and efficiencies will be strongly affected by how the battery is operated. The following general considerations apply only to flooded lead-acid batteries such as golf-cart and fork-lift batteries and other deep-cycle batteries like the L-16 type. These comments do not apply to any type of maintenance-free batteries, sealed batteries, nickel-cadmium, or nickel-iron batteries.

High charging currents from a large PV array or a battery charger connected to a generator can give rise to battery voltages that are very high (2.5–2.7 volts per cell: 15–16 volts [12-volt system], 30-32 volts [24-volt system]) even when the battery is almost fully discharged. In a similar manner, high discharge currents can show low battery voltages when the battery is near full charge. These voltages are the result of the high charge or discharge currents acting through the internal resistance of the battery which also changes as the battery state-of-charge changes.

Batteries are designed to operate most efficiently at 80°F. If the average temperature is higher, they can deliver higher than rated capacities, but cycle life is shortened. If the average temperature is lower, the capacity will be lower and the life a little longer. Cold batteries in PV systems are like cold batteries in cars. Significant amounts of energy are required to warm the battery to a normal operating temperature, and not much of the early charging current ends up as stored electrons. Temperature compensated charge controllers address this cold-weather problem to some extent by increasing the cut-off set points as the temperature decreases, but they do not change the cold temperature chemical reactions nor eliminate the problem entirely.

While amp-hour efficiencies can reach 90% under ideal conditions, amp-hours cannot do work. Only energy measured in watt-hours can do work, and at the very best, batteries can return only 75% of the energy stored in them. To achieve even these efficiencies, batteries must be subject to ideal conditions. They must be at 80°F. They must be charged and discharged very slowly. They must be charged and discharged by smooth DC currents. The electrolyte must be uniform throughout the battery, and the battery must not be allowed to sulfate.

When the cell voltage rises above 2.38 volts per cell (14.3 volts on a 12-volt battery or 28.6 volts on a 24-volt battery), the electrolyte begins to gas. At this point, charging efficiency goes down since more and more electrons are used to produce gas than are used to charge the battery. Gassing, however, is needed to stir the electrolyte to keep it from stratifying. If the electrolyte stratifies, then the solution in the battery has a higher concentration of sulfuric acid near the bottom of the cells and a weaker concentration of sulfuric acid near the tops of the cells. When this condition exists, the bottom of the cells are more active in the charge-discharge process and the active material (lead) is consumed at a higher rate. This higher than normal consumption of active material results in loss of battery cycle life and eventual loss of battery capacity. Therefore, although gassing is not an efficient use of PV energy to charge a battery, it is a necessary function. Some large industrial batteries have provisions for mechanical or air-bubble stirring and therefore do not need to be gassed.

If batteries are not fully charged on a regular basis, the lead-sulfate crystals that are part of the normal charge-

discharge process tend to get larger and harder. These harder crystals are difficult to remove with the normal charge process, so battery capacity is lost and may not be recoverable. Full charging on a regular basis is necessary, and the so-called equalizing charge is also necessary to ensure that the weakest cell in the battery receives a full charge periodically.

Batteries that are subjected to pulsating currents, either from a charger in an inverter or from a series regulating relay or PWM PV charge controller, may be subject to shorter life spans than batteries that are charged with pure, non-pulsing DC currents. Even though the average current may be the same, the higher peak values in the pulsed currents may cause deterioration of the batteries at a rate that is not proportional to the average current.

Users of PV systems must realize that batteries only store energy, and not very efficiently at that. The average amount of energy that the PV system can deliver to the load is limited by the average amount of energy that the PV array can supply minus the losses in the battery and other equipment like the charge controller and the inverter. While the batteries can store several days worth of energy for cloudy day operation, that energy must be replaced by the PV system. While it is being replaced during subsequent sunny days, there will be less PV array energy available to support the load. Examples of systems that were operated without this knowledge were well described by Dennis Ramsey in his article “Nepal PV Upgrade” in *Home Power* #56.

Users of batteries in PV systems should be aware of the other widespread uses of these same batteries. Golf cart and fork lift batteries are used every day to near the point of full discharge. They are then fully recharged every night with a period of gassing included to stir the electrolyte and to ensure full charge of all cells. The motion of the vehicles carrying these batteries also helps to keep the electrolyte stirred. In most cases, the batteries are recharged in areas where the temperatures are somewhat controlled.

**For Those Technically Inclined**

Papers presented at battery conferences indicate that the only reliable method of determining the health of a battery system is to do a discharge test. A load is applied to the battery bank that draws the rated current (usually at a 20 hour rate). For example, a set of 12 Trojan L16s in a 24-volt system is rated at 1050 amp hours. At the 20 hour rate, the discharge current should be about 52.5 amps (1050/20). The discharge current is measured until the battery voltage drops to 1.75 volts per cell (10.5 volts for a 12-volt battery or 21 volts for a 24-volt battery). The discharge current is integrated over time (electronically or graphically) to determine the actual amp-hour capacity of the batteries. It is informative to perform this test on batteries in actual daily service and again after the batteries have received a long equalization charge. With this data, it is possible to determine the condition of the batteries and to make some assessment as to the quality of care that normal operation is providing. Higher capacities measured after an extended equalization charge may indicate that more frequent operation above gassing point is required.

Specific gravity measurements with a hydrometer do not give an absolute measurement of the cell capacity or condition. They can, however, be used to determine when a cell has reached maximum state-of-charge; the specific gravity does not continue to increase with continued charging. They can also indicate when an equalizing charge has been completed; the specific gravity of each cell is maximized and all cells show similar specific gravities.

**The Conflicting Requirements**

As we review these facts, the difficulty in charging batteries with a PV system becomes evident. Batteries should be charged slowly for greatest efficiency, but PV energy is available only a few hours each day. Even increasing the array size is not always practical because the amount of current that the batteries can absorb at any time is limited by the battery voltage which should remain below the gassing voltage for best efficiency. Charging a battery above the gassing point appears to be necessary, although inefficient, because the batteries must be fully charged periodically and the electrolyte must be stirred to avoid stratification. Charge controllers should monitor both battery voltage and battery current to accurately control the charge process.

It should be noted that a battery can be brought to a full state of charge while holding the voltage below the gassing point. This is an efficient way to charge a battery, but it takes a very long time because the currents are so low. Also, it should be noted, that merely operating a battery above the gassing voltage does not guarantee that the battery will be fully charged. High charging currents can gas a battery that is only partially charged. Given the PV and generator charging systems available to the RE user, it appears that charging the batteries above the gassing voltage with the generator and/or PV array is the only practical way to ensure a fully charged battery in a reasonably short time. It isn’t an efficient process, but it is a necessary one until some other technology comes along.

### PV Array and Battery Considerations

For maximum battery life and maximum system efficiency, the following general rules have evolved. They are not always easily implemented and are subject to change as new technologies and information become available.

The old adage "Make hay while the sun shines" certainly applies to PV systems. If energy from the PV array is used during the daylight hours when it is being produced, then battery losses will be minimized because that energy will not be stored in the battery. It will be used directly by the load. If and when the charge controller starts regulating (reducing) the current into the batteries each day, the excess energy should be diverted to good use. These include pumping water, washing clothes, ironing, and cranking up the furnace.

Normally, a PV array is sized to handle the average load based on an average amount of sunlight. This design procedure assumes that there will be lots of sunny days following cloudy days so that the battery will be recharged. It may be better to slightly oversize the PV array (above the average load requirements) so that the batteries can be assured of a quick return to full charge after a cloudy period. Unfortunately, in periods of extended good weather, this design method will result in excess energy being available that cannot be used. Optional loads like watering trees or pumping water into storage containers might be considered to use this excess energy.

The PV array must be sized so that there is sufficient energy to recharge the battery while supplying the daytime loads. Loads that are excessive or an array that is too small will result in continual under charging of the batteries.

Oversizing the array can be avoided, if a backup generator is used. If the system is designed to use the generator on a regular basis to supply the loads, then the PV system with generator is called a hybrid system.

With a hybrid system it is usually best to run the generator after sundown to carry the heavy loads and recharge the batteries during the night-time hours. The next day, the batteries are fully charged and the relatively expensive PV energy can be used to supply the daytime loads rather than being used to recharge the batteries with the resulting losses in energy. Since the generator is being used every day or two, it can be used to fully charge the batteries, gas them regularly, and stir the electrolyte.

Running the generator under full load will result in better fuel efficiency, but juggling loads and battery charging are not always straightforward or easy. As the batteries enter the gassing region, the battery charger (usually in the inverter) will taper the current from the generator. If there are more loads that can be operated at this time, they should be turned on to keep the generator fully loaded.

Night-time operation of the generator is possible only when it will not disturb the household or nearby neighbors.

### Can All This Be Automated?

Are there off-the-shelf control systems that can do all these things? The short answer is no, but such devices are on the drawing boards and may be available in a year or two. To achieve all of these somewhat conflicting goals will require integrated computer control of the PV array, the generator, and the loads. Battery voltage, battery currents, available loads, and time-of-day information will be needed. This level of automation may not be practical or desirable in the renewable energy system. Even with automation, it is rarely possible to match load availability with PV/generator energy production on a daily and seasonal basis.

At the present time, there are combinations of devices that can achieve some of these control requirements and, when coupled with manual load control, can approximate the desired functions.

Three-stage PV charge controllers that have two set points for voltage control are now available. These PV controllers feed maximum current from the PV array into the batteries (constant current charging) until the battery voltage reaches some bulk voltage set point that is above the gassing voltage. The charge controller holds the battery voltage at this point for an hour or more to ensure that the electrolyte is fully stirred. Unfortunately, PV energy is lost during this period because the charge controller limits it and the gassing itself is inefficient. After the set time has elapsed at the bulk voltage, the charge controller then lowers the voltage below the gassing voltage to a point known as the float voltage. This voltage allows limited current to continue to charge the batteries without gassing and without the loss of water associated with gassing. These controllers also have automatic equalization cycles every 30 days where the set points are raised even higher for a timed period to ensure that all cells in the battery are fully charged.

PV charge controllers that have only a single set point essentially regulate the battery voltage at one voltage. If the average battery voltage resulting from that single set point is below the gassing voltage, then the electrolyte will not be stirred. If the voltage is set above the gassing point, then the user runs the risk of excessive gassing and water usage, particularly if the

system is left unattended and/or unloaded for long periods (vacations). These controllers may have to be adjusted seasonally and at other times when the average daily load profile changes significantly.

There are inverters that have three-stage charge controllers that operate in a manner similar to the PV charge controllers described above. In a hybrid system, where the generator is operated every day or so, or at the very least once a week, the set points in the inverter charger can be set to provide the necessary gassing function and even the equalization function. This type of inverter/charger could be used with a single-stage PV charger with the PV controller set point selected to be just below the gassing voltage.

All charge controllers, both PV and inverter/generator should be temperature controlled. This is a requirement even when the batteries are installed in an 80°F temperature-controlled room because high-current charging of the batteries can increase the internal temperatures above a safe value.

There are diversion charge controllers that can take excess energy (that the batteries cannot use) and feed it to diversion loads such as hot water heaters or water pumps. There are also voltage-controlled switches that can sense battery voltages and turn on loads that will absorb the excess energy.

**How Do I Manage My RE System?**

In the Spring and Fall when my loads are relatively small—no heating or cooling fans to run, I do the following:

I set the three-stage charge controller in a normal mode that gasses the batteries every day. Since this happens by mid day, the batteries are in the float mode for several hours each day and are operating near a full state of charge. When the batteries are in float mode, there is excess PV energy available that would otherwise be lost—the PWM controller starts regulating and reduces the average array current going into the battery. When the float indicator comes on, we generally do those household chores that require extra energy such as clothes washing and vacuuming. I do have a diversion load that could be used to absorb excess power to heat water, but my solar hot water system produces more than we need already.

Once a month, I equalize all cells to ensure that they are fully charged. I remove the Hydrocap vents from the batteries, reinstall the standard caps, push the manual equalize button on the charge controller and start the generator. I set the inverter charge points to an equalize setting and use both the generator energy and the PV energy to fully charge the batteries for 10-12 hours. The batteries are regulated to about 31.5 volts on my 24-volt system (2.63 volts per cell) and any DC load that would be damaged by this battery voltage is turned off. Since I have excess generator power available as the batteries reach the set point, we mow the grass, pump water to water the grass, do the laundry, and vacuum cleaning, and otherwise keep the generator fully loaded. After the generator is turned off, I check the battery water and then reinstall the Hydrocap vents. The PV controller is reset to the normal mode.

In the Summer and Winter, we have 3/4 hp fans on the swamp cooler and furnace that move air for cooling and heating. These are significant loads, and on a typical day, the total loads can exceed the PV array output. The PV charge controller is set as above. If the available PV energy is insufficient in any given week to get the batteries to a float condition (at least three days), I run the generator one evening a week for 4-6 hours to get the batteries into the gassing region for at least three hours. The inverter is not set to equalizing voltages and the Hydrocap Vents are not removed. Household chores are still done in midday when the sun is shining and during the generator run time. During the short Winter days, we do the laundry in the evening and use the gas clothes dryer at night while the generator is running. In the Summer, the longer days make it possible to turn the large loads off (on cooler days), and equalize the batteries with just the PV array once a month. In the Winter, it is usually necessary to run the generator in an equalize mode once a month as described above. During these seasons, we try to get out of the house at least one day a week for rest and recuperation (R&R). This allows us to turn the big loads off and let the batteries have a day of R&R also.

**Summary**

If all of the above information seems overly confusing and complex, then just relax and enjoy your renewable energy system as it is. While it may not be as efficient as it could be, and the batteries may not last as long as they could, it has and probably will continue to satisfy your energy needs.

**Access**

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COMM.POWER

# Save Energy with Electronic Communications

Michael Welch



A lot of our lives and resources are spent transferring information. Until recently, most information was either spoken or written. But in modern times, information can be transferred electronically and stored for use at the time and convenience of the recipient and without consuming permanent resources like paper or stone tablets.

What's information? Information specialists spend years studying the nuances of the word. Theories abound that deal statistically with the measurement of its content and characteristics. It is easiest to define what it is not.

Information is not a piece of paper or any other kind of media. It is not the mail, a newspaper, an advertising agency, a voice, a magazine, a diskette, or a computer file. It is easy to confuse the information with the vehicle that carries it. It is the information itself which gives the vehicle most of its value.

The way information is presented within its vehicle helps determine how useful and attractive it is. For example, *Home Power Magazine* could easily print enough raw data logged from PV tests to fill the magazine. But this is not the presentation readers need. What helps make the information useful is the interpretation and style that is provided by our publisher. We want to see photos of the PV modules and have comparisons made, or the information is nothing but raw, barely usable data.

A second component of the value of information is time. Almost every morning I buy a newspaper. If I open up the rack and find yesterday's papers, I feel ripped off. Yesterday's news I've already gotten. Yesterday's newspaper lost most of its value from when it was today's news (yesterday). With the exception of a few copies needed for archival purposes its only value is as a recyclable material.

### Different Strokes

A very important factor in the usefulness of information is the recipient's preferences. Different strokes for different folks. Back to the newspaper. One of my favorite times is relaxing in the morning with the paper, a cup of coffee, and a bagel from Los Bagels. I can easily choose which articles to read and when to read them. If it was an aural media I'd have to listen to an entire broadcast or fast forward on a tape or disk to the sections I wanted. If it was an electronic media, I'd have to chain myself to a computer at breakfast. But, other people prefer to get their daily news electronically from news services that clip stories from many sources based on the recipient's stated parameters. Each day a file of information is E-Mailed (electronically mailed) to the recipient. A busy person might set their parameters so that they only get clippings containing the subject(s) photovoltaics, Bosnia, or whatever.

Also important is the amount of natural resources that a particular information vehicle consumes. Newspapers, magazines, and postal mail all take a toll on our environment. Millions of trees and untold megawatts of energy are gobbled up every year by the pulp and paper industry just to provide a delivery platform. Postal mail has another resource cost that should be added in. Every business letter costs the sender two dollars or more, aside from the actual writing of the information. This includes the obvious costs of postage and an envelope, but something most folks don't think about is the amount of time it takes someone to format the letter for letterhead, print, proofread, get the final signature, make a copy for archives, stuff, seal, and stamp the envelope, and then deliver it for post office pickup. In business, time is money.

### E-Mail Saves Time, Money, and Resources

While not appropriate as a replacement for all forms of postal mail, E-Mail can save resources. Once an E-Mailable message or piece of information is written on the computer, there is no need to use paper, no need for per-piece postage, and only a tiny amount of extra electricity is required to operate modems and transmit the message over the Internet. This form of communication of information may not be as intuitive as sending postal mail, but once the vehicle is in place and the sender and recipient know how to use it, the ease

and speed of use surpasses even the simplest and quickest forms of postal mail.

Sending an E-Mail message is nearly instantaneous. If I were to postal mail a friend in Australia, for example, a letter could take weeks before it's received. That would be a good choice if I were sending a specific item like a special photo they accidentally left during a visit here. But, if what I were sending was pure information, like a text message, then using E-Mail will get it to the Australian friend's Internet Service Provider within moments. Then it is only a matter of my friend modeming to their own ISP to pick up the message and read it when convenient.

No paper, no dead trees, no Air Mail postage, no significant amount of electricity, no time zone hassles, no long distance phone charges, no vehicles burning dead dinosaurs, no photocopying, no anything. Just pure information delivered quickly and quietly. The data was but a tiny blip in the phone lines, and only takes up about a hundred thousandth of the space available on the computers' hard disks. It can be easily saved and archived and even passed on to other friends, via either E-Mail or reusable computer diskette. It can also be deleted without adding to our world's burgeoning solid waste disposal problems. Finally, if need be, it can still be changed into a "hard copy" on paper via a computer's printer.

One potential glitch in using E-Mail as a substitute for postal mail is security. While it is true that postal mail can be intercepted, the opportunity is a bit greater with E-Mail. With a postal letter, it can be seen whether or not it has been opened but with E-Mail, there is no way to tell if someone had a look at or even changed the data between the sender and the recipient. There is a way around this that is commonly used in business circles and can be used by anyone. Encryption software can be used for the body of the message. The sender is given an electronic filter that changes an E-Mail message in a way that makes it readable only to the person that has the encryption "key," normally the recipient. The code used to encrypt messages like this is so deep that it can take banks of specialized computers thousands of hours to try all the possibilities for breaking into the code. Data encryption makes E-Mail far more secure than postal mail is.

Another potential glitch is the loss of E-Mail in the Internet pipeline. It's unlikely, but usually there are correctable problems involved. Even when a message is assumed lost, the quickness of the Internet makes it easy to replace a message in a timely manner.

The most common E-Mail delivery problem is that the sender did not have the correct address of the recipient. One wrong or out of order character in an address is enough, but usually those message get bounced back to the sender with an error message saying the mail was undeliverable. Another problem is when one of the router or mail server computers in the Internet network crashes before it has a chance to pass on an E-Mail message it has received. A third E-Mail glitch that I recently saw happened because an ISP has his equipment set up to reject E-Mail files larger than a certain size. Shame on him. What gives him the right to throw someone's mail away just because it contained a data file that was larger than 1.99 megabytes?

**Telecommute To Work**

Lots of people have jobs that deal mostly with information. It makes a lot of sense for people not to have to drive to a job just to create, manipulate, and/or disseminate information. They can do it from home or elsewhere. I am a good example of this, writing this article 250 miles away from *Home Power* Towers. It could just as easily be 4000 miles. When finished I will E-Mail the text to Richard, who checks for E-Mail daily.

I also produce and maintain World Wide Web pages for several clients, only one of which is in my community. After designing and fine tuning the graphics and text on my own computer, I upload the files over the Internet to the clients' Web servers located all over the West. It doesn't matter where, I can get the information there from the comfort of home.

**Online Research**

As a writer I find that I can do a lot of my research work while online, saving considerable time and money. One source of information are the mailing lists I subscribe to. A mailing list is set up on an ISP's mail server, and usually is limited to a specific topic such as utility deregulation, advances in utility scale renewables, etc. Anytime the list owner has info to be distributed, they send it to the mailing list. If my E-Mail address is included in that list I automatically get the information. Many of these lists are set up so that I or any of its subscribers can also send information to that list which then gets distributed to all the list's addresses.

Another vast and growing area of electronic information is the World Wide Web. I use it for research regularly. Anybody can put information on the web, as long as they have access to a site. Usually people that put info on the web do so because they have an agenda (but many do it just for fun). This means that every time you get a piece of info from the web, it must be scrutinized for truth, accuracy, and context. For example, a search for information on California Congressman Frank Riggs (R, 1st District) turned up about 600 Web pages with his name included. A quick review of these sites owners' names show where their prejudices are likely to

lay: Women's Information Network, Citizens' Flag Alliance, California Republican Party, and my own favorite, RiggsWatch, which watchdogs Rigg's actions.

**Searching the Web**
I used a free online search facility called Alta Vista (http://www.altavista.digital.com/). There are others, but I like Alta Vista because it is fairly complete and very fast. They have computers that stay on the Internet and search out every World Wide Web page they can find. Every time one of these automated computers finds a new web page, it automatically indexes every word of the page into a database, looks for key words, and looks for links to other pages so that it can move on and index those pages as well. Using the assumption that every page in the world will have a link to or from some other page, these searchable indexes will eventually find every new page. A query of Alta Vista results in lists of short descriptions and hot links directly to the pages described so that you can easily jump to the pages that match your query.

With millions of World Wide Web sites throughout the world, a lot of narrowing down of a search must occur. For example, an Alta Vista search for "photovoltaic" gave me 10,000 web pages that matched my query. Adding a second search word "battery" narrowed it down to 1,000 matching web pages. Adding the phrase "Home Power Magazine" into the search query further narrowed it down to 17 web pages, a manageable number.

As you can see, there is a wealth of information out there on the Internet that provides utility above and beyond the ability to E-Mail back and forth with your correspondents. Two other Internet information retrieval methods that I occasionally use are FTP and Gopher. Simplistically stated, they are methods for obtaining and finding computer files that have been archived on various servers throughout the Internet.

**How Do I Get on the Internet?**
You need four things: a personal computer, a high speed modem, an Internet Service Provider, and Internet software. It doesn't really matter which kind of personal computer you use, but some of the older computers may not be able to work with a high speed modem and/or may not be able to run modern communications software. Most people are either using Macs or PC's. Color monitors make the World Wide Web experience most enjoyable.

Many new computers come with high speed modems built-in but if you find yourself in the position of needing to purchase a modem, I highly recommend sticking with the better made, albeit more expensive, big name modem manufacturers. You get what you pay for. I like US Robotics, Microcom, Supra, Practical Peripherals, Global Village, and Hayes. You can count on these modems giving you years of reliable service.

Choosing an Internet Service Provider can take some research. An ISP is usually a for-profit company that has a bank of modems for your computer to dial into. Their modems are hooked up to a network router that allows you access to the ISP's own servers and is connected via special high capacity phone lines to the Internet. From there, you can go anywhere on the Internet. Most communities have one or more ISP's. They normally cost around $20 per month for enough online time to do what most people need, with extra per-hour charges for going beyond the permitted time allotment. Most ISP's will also give their subscribers a free place to put their own World Wide Web pages.

I recommend staying away from the huge providers like America Online, Compuserve, and Microsoft Network. They often have problems with too many people trying to access them at a time, poor technical support, slow modem connections, and I like to recommend that folks support local businesses.

To find and comparison shop your local ISP's, look in your phone book's yellow pages under "Internet." A quick check in our phone book for this mostly rural county lists 6 possibilities. Ask around of people that have used each of them to find out which will give you the most satisfaction. Then ask each pointed questions about their service and setup: Do they offer technical support without frequent busy signals? What is their ratio of incoming modems to number of registered users? Unscrupulous ISP's will oversell their capabilities, resulting in busy signals on modem lines and frustratingly slow throughput. What is their ratio of registered users to the number of the special T-1 phone lines that connect them to the Internet? Where do they contract their services? This last is a crucial question as the speed and reliability of your connection to the Internet is directly dependent on the speed and reliability of every Provider that your own ISP has to go through to get to the "backbone" or main routers on the Internet. Like you, ISP's also contract their connections to the Internet through other ISP's. Like a water delivery system, the speed of an Internet connection is no better the size of the smallest pipe between you and your destination.

**Internet Software**
You can use whatever Internet software you choose, but when you go with a large, national online service, you are often saddled with the software that they provide. Their software can get you from their own specialized network out into the Internet, but they make

it very difficult for you to switch over to the more popular Web software like Netscape. When you choose a local ISP for your Internet service, they usually provide you with a disk of software that you need as well as instructions on how to set it up. If not, then you can purchase a commercial solution from a software vendor like Internet In A Box. Either way, it will include the "dial-up" software that gets you onto the network and a bare-bones E-Mail software package, but normally the Web browser that comes on these disks is not the latest released by the software company. In that case, you would need to log onto the software company's Web site and retrieve the latest version.

Most folks find the World Wide Web and E-Mail to be their major usage of the Internet. Recent versions of Netscape and Internet Explorer can provide all the access you would normally need to your E-Mail, the Web, Newsgroups, and FTP sites. When it comes to Web access, they are the full featured solution, but they handle E-Mail as something of a sideline to their actual purpose. For a full featured E-Mail program, I recommend Eudora Pro. It is robust and will do everything you need to do in the world of E-Mail. It is not free but they make Eudora Light which is still very good software and is often included on the complimentary setup disks that come from your ISP.

Many new computers come pre-loaded with the software you need to dial into the Internet. Caution must be exercised though, because often they are set up to dial into the big online services, and you must figure out how to make it usable for a local provider, if that's your choice.

**Electronic HP Distribution**

*Home Power Magazine* has been distributed strictly in its paper printed format for many years. It bothers us to know that trees and dead dinosaurs are being consumed to get the job done. Most of our readers find a lot of value in keeping back issues of *HP* around, so we feel OK that *HP* is printed on paper, and we try as much as possible to use "good" paper like recycled chlorine-free stock (and maybe someday tree-free paper like hemp or kenaf). But we've long dreamed of finding a paperless way of publishing.

One way we've been doing this is to offer our back articles on the Solar1 CD-ROM, and we are working on the next version of that CD that will offer more complete versions of our back issues. But we would still like to offer our current issues electronically. We looking into offering electronic subscriptions to *HP* via E-Mail or by downloading from our Web pages.

There is a type of computer files called the Portable Document Format (PDF). It allows us to take our desktop publishing files (just like they go to the printer) and render them into an electronic version that views on a computer screen. The software to read PDF files is called Acrobat Reader and is available for most computer platforms. Adobe gives this software away from their Web site, http://www.adobe.com/Acrobat/readstep.html.

Check out PDF technology by going to the "lead article" from our Web site, http://www.homepower.com. We want to offer the entire issue in this way, complete with cover and advertisements.

This new subscription method will be most advantageous for our International subscribers who often have to wait weeks or months to receive the latest issue of *Home Power* and for those that just don't want to wait for the local mail to arrive. It will be available even before those with U.S. First Class subscriptions get their hands on it. Also, it will be cheaper for us to print and send since we don't have to pay for hard copy printing or postage costs.

This format is not without its disadvantages, though. The files will be quite large. We expect the electronic version of *HP* to be around 5 megabytes. As a file enclosed in an E-Mail message, this can take about 40 minutes to retrieve. Another disadvantage is that it is difficult to have an electronic version of *HP* laying around on your coffee table, although Acrobat Reader supports modern computer printers.

Obviously, this new method is not for everyone. There's a lot to be said for thumbing through the latest issue with high resolution graphics and a reading lamp next to the fireplace. But for those that want it quick and for those that want to be "part of the solution," this new option could work out well.

**Access**

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# Training and Accreditation

Don Loweburg



Mark Fitzgerald, editor of an early PV industry magazine *Photovoltaics International* (*PVI*), shares the following information about two projects that he is working on:

The Global Accreditation Program (GAP) for Photovoltaics is an international organization compiling and establishing standards for PV equipment and installation. The Institute for Sustainable Power, Inc (ISP) is also working on a certification project in parallel with GAP. ISP maintains a Web site that has PV information and directories. ISP will be having a PV Training Summit at SOLAR 97 this Spring in Washington, DC. Billed as a participatory and working meeting, early registration is requested. See access.

**SCE Sunset**

Southern California Edison (SCE) announced at the Fifth Semi-Annual PV Compliance Workshop on January 14, that both the Off-Grid and On-Grid PV Pilot Programs would terminate at the end of their proscribed time periods, May 5, 1997 and January 1, 1998, respectively. Ray Paz, head of Dispersed Applications at SCE, did not give detailed reasons for the policy shift but emphasized that Edison would honor all contracts and commitments made under the programs.

Those of us attending the PUC mandated workshop received summaries of the program's progress. From that information one could generalize that under-subscription is the main problem with the programs. Pooling information from both programs, there were just eight residential systems installed or to be installed as of January 14. It's interesting to note that this is exactly the conclusion indicated by *Home Power's* own survey published here over two years ago—the public does not perceive the utility as a likely or desirable provider of PV power and service (Especially since there are local PV businesses with expertise and technical experience practically everywhere). Is Edison really throwing in the PV towel? We shall see. Their RD&D division still has a significant budget. Another strong possibility is that one of their new unregulated "affiliates" will handle Photovoltaic and Distributed Generation activities.

**Who Owns the Sun?**

This certainly is not the first time that this question has appeared in *Home Powe*r. It's rhetorical, one we already know the answer to: Nobody owns the sun. The purpose of this questions is to set the stage for inquiry. Berman and O'Connor, the authors of *Who Owns The Sun?* just published by Chelsea Green Publishing Company, do a good job of exploring that stage.

Subtitled "People, Politics, and the Struggle for a Solar Economy," the book's authors systematically examine the "big picture" surrounding energy use and the future possibilities of mass utilization of solar energy in the United States. Each chapter focuses on a specific issue in historical perspective. Some of the areas explored are The Solar Movement of the Seventies, Early Solar Water Heating in Florida and California (and its demise), The Rise of the Carbon Cartels, The Growth of the Monopoly Electric Utilities, The Growth of Public Utilities, The Role of Labor in the Energy Industry, Corporate Greenwashing, and Solar Homesteaders. No chapter or idea is separate from the others. What the authors do is weave a story with threads of time and subject. The goal is to comprehend the situation as it presently is and to outline what and why changes must happen. Extensive footnotes make this book an excellent reference work as well as a good read. This book is very much recommended, both for those who are just learning about energy efficiency, load management, renewable energy, local distributed generation, and for those already on that "softer path."

This review cannot and should not tell the whole story of Who Owns the Sun?. For that, one must read the book. I would like to discuss the question of "politics." Frequently one is admonished not to get too political or that one should not politicize a particular issue. Yet, around issues like quality of life, liberty, and

independence, how can one not be political? This is the core stuff of deep politics. I do believe that issues such as air pollution, balance of payment problems caused by importing most of our energy, access to, and fair prices for electricity framed in conventional political terms, has not served the populace. In fact, I believe that framing energy issues in those conventional political terms (right-left, Republican-Democrat) has often served the interests of centralized power and capital rather than the consumers of energy. This is because often Republican-Democrat squabbles create great diversions capturing national attention while energy corporations quietly lobby in the background, taking care of business. I recall, with sardonic humor, reports that Howard Hughes routinely contributed generously to both the Democratic and the Republican parties. This is the real “win-win” policy envisioned by corporate capital and it is very much the rule of the day. Throw in “Greenwashing” and the power of advertising and it becomes very difficult for the average citizen to know or influence what’s going on. So what are “we the people” to do? Berman and O’Connor, the authors, of *Who Owns the Sun*, suggest a direction. It’s a deeply held American tradition (Remember the Boston Tea Party?). It’s called local action and control. Whether it’s owning PV connected to your grid-tied home, installing PV on your off-grid home rather than extending utility wires, organizing a municipal co-op to purchase electricity directly from independent power providers (hopefully renewable), or purchasing power from green marketers like Working Assets that guarantee a given percentage of renewable energy; these kinds of actions can make a difference and shape energy use in the 21st Century. No matter what your political persuasion, patriot, radical, conservative, liberal, Republican, Democrat, or just an average person, read this book!

**Tidbits**

If you are interested in utility news, try this web site at www.energycentral.com. From 20 to 40 news summaries are posted daily. If you register, the summaries will be sent to your E-mail address at no cost. If you wish to download the entire article then you must pay. As an overview of industry activity this service provides a wealth of information. Some tidbits gleaned over the last week: under “Plant Events” over half the articles listed involve maintenance or breakdowns at nuclear plants, a large number of takeovers and acquisitions (the big sharks are eating the little sharks), consistent reports from around the country that utility workers are being laid off, and in state after state restructuring is moving forward with probable Federal involvement soon. By the way, a growing number of ratepayer groups are questioning the bailout of utility nukes (don’t hold your breath though).

**Access**

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The Global Accreditation Program (GAP) for Photovoltaics, Dr. Peter F. Varadi, Tel./Fax: 301-657-9110

The Institute for Sustainable Power, Inc. (ISP)
Web: www.pvpower.com

*Who Ownes the Sun*, by Daniel Berman & John O’Connor, ISBN 0-930031-86-5, Chelsea Green Publishing Co., PO Box 428, White River Junction, VT 05001
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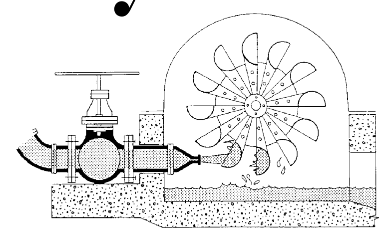
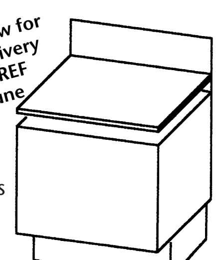
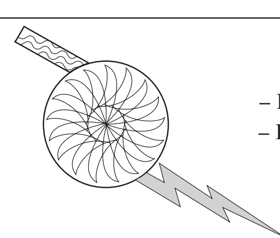


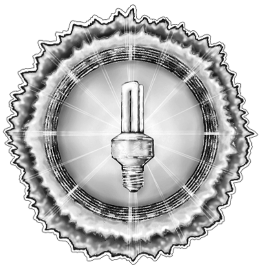








# Home Power's Business



"The man who on his trade relies
Must either bust or advertise."
Sir Thomas Lipton — 1870

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# Code Corner

## Ground Fault Protection and PV Checklists

John Wiles

*Sponsored by the Photovoltaic Systems Assistance Center, Sandia National Laboratories*

This month's Code Corner will deal with two subjects. The first is a discussion of Section 690-5 of the National Electrical Code (NEC) that requires ground-fault protection equipment for PV arrays mounted on the roofs of dwellings. The second subject presents a check-list that can be used to ensure NEC compliance in a PV installation.

**Ground Fault Protection**

NEC Section 690-5 requires that a ground-fault protection device (GFP) be used on PV arrays that are installed on the roofs of dwellings. Inspectors in Oregon, Colorado, New Mexico, and elsewhere are requiring this device which has been an NEC requirement since 1984. The electrical engineers at the National Fire Protection Association (NFPA) who officially interpret the NEC are telling inspectors that this is a valid requirement and that the PV industry is behind in making the device available.

As spelled out in the NEC, this GFP is intended as a fire protection device and not a shock protection device (GFCI). In the 1996 NEC, the GFP must detect fault currents, interrupt these fault currents, and then disable the array. The only effective method of automatically interrupting the fault currents is to unground the PV array. Disabling the array is controversial with the NEC Handbook suggesting that both conductors to the array be disconnected from the load and then shorted together. Some PV manufacturers maintain that this shorting action may damage modules in high-voltage PV arrays.

There are several devices on the market that meet the NEC requirements. They are manufactured by Alternative Power Technologies-previously Ananda Power Technologies (916-478-6645), and Trace Engineering (360-435-8826).

If the price is too high and the inspector still requires such a device, consideration should be given to moving the array off of the roof of the dwelling.

**Solar Photovoltaic Systems Checklist**

The checklist presented below can be used in the initial planning stages of a PV system. It is designed for use by an electrician or electrical contractor to ensure that the PV-specific requirements of the NEC are met. It is not meant to be an all-inclusive design or installation guide. Specific details have been covered in past issues of Code Corner in *Home Power Magazine* and will be covered again in future issues.

The following checklist is an outline of the general requirements found in the 1996 National Electrical Code (NEC) - Article 690 for Photovoltaic (PV) Power Systems installations.

This list should be used in conjunction with Article 690 and other applicable articles of the NEC and includes requirements for both stand-alone PV systems (with and without batteries) and utility-interactive PV systems. Where Article 690 differs from other articles of the NEC, Article 690 takes precedence [690-3].

References in brackets [ ] are to the 1996 NEC and other relevant documents.

**PV Arrays**

- Listed PV modules are available from 4-5 manufacturers [110-3].

**Conductors**

- Conductor type-USE-2, UF, or SE if exposed [690-31(b)]; RHW-2, THWN-2, or XHHW-2 in conduit [310-15]. 90°C, wet-rated insulation is necessary [UL-1703].
- Temperature derated ampacity calculations should be based on 125% of short-circuit current (Isc), and the derated ampacity must also be greater than rating of overcurrent device (156% Isc -see below) [690-8,9].
- Suggest derating factors of 60-65°C in cooler areas, 70°C in hotter areas, and 75°C in desert areas be used for ampacity calculations.
- Portable cords are allowed only on moving tracker connections [690-31(c), 400-3].
- Strain reliefs/cable clamps or conduit should be used on all cables and cords [300-4, 400-10].

**Overcurrent Protection**

- DC-rated and listed fuses and circuit breakers are available from several sources. If device is not marked DC, then verify DC listing with manufacturer.
- Rated at 1.25 x 1.25 = 1.56 times short-circuit current from modules [UL-1703, 690-8, module instructions].
- Supplemental devices allowed, but branch-circuit devices preferred [690-9(c)].
- Located near the charge controller or battery [690-9(a) FPN].
- Must protect smallest conductor used to wire modules. Sources of overcurrent are parallel-connected modules, batteries, and backfeed through inverters [690-9(a)].

**Charge Controllers**

- Listed devices are available separately and inside listed PV load centers [110-3].
- There should be no exposed terminals—at least one listed unit has exposed terminals.

**Disconnects**

- Listed, DC-rated devices are available: Square D QO breakers for 12-volt DC systems, Square D Heavy Duty Fused Safety Switches up to 600 volts DC.
- Listed PV Load Centers by APT and Trace for 12, 24, and 48-volt systems contain charge controllers, disconnects, and overcurrent protection for entire DC system.
- Must provide disconnects for all current-carrying conductors [690-13].
- Must provide disconnects for equipment [690-17].

**Inverters (Stand-alone Systems)**

- Listed stand-alone inverters are available from three manufacturers [110-3].
- DC input currents must be calculated for cable and fuse requirements: Input current = rated ac output in watts divided by lowest battery voltage divided by inverter efficiency [690-8(b)(4)].
- Cables to batteries must handle 125% of input currents [690-8(a)].
- Overcurrent devices should be located within 4-5 feet of batteries.
- Overcurrent/Disconnects mounted near batteries and external to PV load centers are suggested if cables are longer than 5-6 feet to batteries or inverter.
- Listed, DC-rated fuses and circuit breakers are available. AIC should be at least 20,000 amps. Littelfuse marks DC rating, Bussmann and others sometimes do not [690-71(c), 110-9]. Verify listed, DC-rating with manufacturer if unmarked.
- 120-volt inverters connected to 120/240 load centers with multiwire branch circuits have the potential for neutral overloading in the branch circuit [100-Branch Circuit, Multiwire].

**Batteries**

- None are listed.
- Cables should be building-wire type cables [Chapter 3]. Welding cables and auto battery cables don't meet NEC. Flexible USE/RHW cables are available. Article 400 cables OK for cell connections, but not in conduit or through walls [690-74, 400-8]. See stand-alone inverters for ampacity calculations.
- Access should be limited [690-71(b)]. Install in well-vented areas (garages, basements, out-buildings, not living areas).
- Cables to inverters, DC load centers, and/or charge controllers should be in conduit [300-4].

**Inverters (Utility-interactive Systems)**

- Listed units are available from two manufacturers and should be used for safety of utility personnel by eliminating the possibility of energizing unenergized utility lines.
- Must be on dedicated branch circuit with back-fed overcurrent protection [690-64].
- Must have external DC and ac disconnects and overcurrent protection [690-15,17].
- Total rating of overcurrent devices connected to ac load center (main breaker plus PV breaker) must not exceed load-center rating (120% of rating in residences) [690-64(b)(2)].

**Grounding**

- Only one connection to DC circuits (ungrounded conductor) and one connection to ac circuits should be used for system grounding [250-21].
- AC and DC grounding electrode conductors may be connected to the same grounding electrode system (ground rod) [690-41,47].
- Equipment grounds are required even on ungrounded, low-voltage systems [690-43].
- If a 12-volt system is ungrounded [690-41], then disconnects and overcurrent devices are required in

both of the ungrounded conductors in each circuit [240-20(a)].

- Equipment grounding conductors for DC circuits from PV array may be run apart from other conductors [250-57 (b) Ex 2] and this routing is suggested to minimize damage from lightning surges.

**Conductors (General)**

- Standard building-wire cables and wiring methods can be used [300-1(a)].
- Wet-rated conductors should be used in conduits in exposed locations [100 Definition of Location, Wet].
- DC color codes should be the same as ac color codes—grounded conductors are white and equipment grounding conductors are green or bare [200-6(a), Ex 5].

**Questions or Comments?**

If you have questions about the NEC or the implementation of PV systems following the requirements of the NEC, feel free to call, fax, or write me at the location below. Sandia National Laboratories sponsors my activities in this area as a support function to the PV industry. This work was supported by the United States Department of Energy under Contract DE-AC04-94AL8500. Sandia is a multiprogram laboratory operated by Sandia Corporation, a Lockheed Martin Company, for the United States Department of Energy.

**Access**

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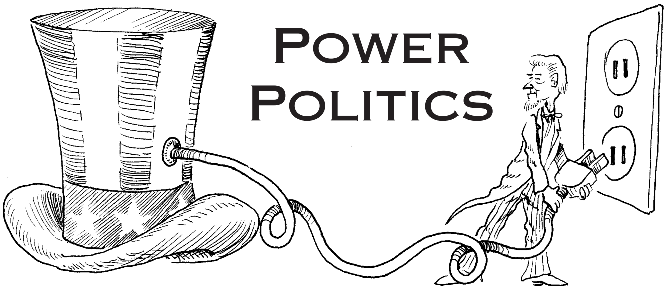


# Armies Invade Washington

Michael Welch



Armies of pasty-faced automatons in grey suits are descending upon Washington, DC. Sound like a lousy grade B movie? Were it only true.

The fact is that these are real people, more or less, in a true life situation. Mostly lawyers working for the nuclear industry, for energy-intensive manufacturers, and for companies wanting to get their feet in the door of a new industry, these hacks are there to make and save millions for their clients. More like a documentary than fiction, what is being played out in Washington, DC may turn out to be a sequel to the long-winded epic in California that resulted in the bad guys winning.

Once again it's utility restructuring time, and everyone is jockeying for position. For example, the Edison Institute spent more than $5 million in 1996 lobbying on behalf of its clients just to help ensure that old uneconomic investments in nuclear facilities will continue to be financially supported by taxpayers and ratepayers. They expect to up the ante on the numbers of lobbyists significantly this year. An article in *The Energy Daily* said that 37 nuclear power sites could be forced to close early due to their uneconomic costs in a deregulated market.

That's a lot of nuke plants and I, for one, would be happy to see them go. The problem is that the utilities have invested up to $5 billion in each one. They did this at a time when utilities were guaranteed a return from ratepayers on their power plant investments, no matter how expensive and uneconomical they were. Now, deregulation threatens that guaranteed income because there is no way the plants can compete in an open market. They feel forced to fight against a true deregulation, claiming it is unfair that the rules are changing against them in the middle of the game. And boy, do they have the power to fight! With so much to lose, a few million spent here and there on armies of lobbyists is a drop in the bucket.

The Edison Institute is only one player. Each major utility also has lobbyists doing their corporate bidding in Washington. The manufacturing corporations and their industry organizations also have an incredible number of suits watching out for their interests, and though those lobbyists have other issues to watch out for, their bosses are starting to focus them on the deregulation issue because so much is at stake. Lots of these companies have electricity costs in the millions annually and some in the hundreds of millions, so a 10 to 50% reduction in their energy bills becomes high-stakes finance. What the heck, a few million invested in lobbying now could result in savings of hundreds of millions over the next few decades.

The other high-stakes companies that are in the deregulation lobbying effort are those that want to buy bulk electricity from power plants at a low rate and then resell at a handsome profit to future customers. A company called Enron has thrown its rather large hat into that ring. They are serious. They even spent big bucks on commercials going to targeted markets during the Super Bowl.

**Coalitions**

So, this begs the question: how does the little person without millions in resources have an effect on all of this? Coalitions of organizations are the answer, but they also present a couple of problems. In California's restructuring fight, a handful of coalitions were formed and one in particular led the battle to get renewables a fair shake. Coalitions are really good at developing consensus among their participating groups. That way when the parties are at the negotiating table or talking to key regulators and politicians, what appears to be a united front is presented, and all of the coalition's resources can be focused on that front.

But this presents a problem in itself. Each of the groups has slightly different agendas, and every one of them must give up something to be part of the coalition compromise. For example, if environmental groups are part of a coalition along with consumer groups concerned mostly about rates, cross purposes will pop up. Protecting the environment costs money, something that is difficult for many consumer organizations to support. Likewise, purely saving money is not considered as high a purpose as investing in the

environment to a lot of groups caring for the earth. A compromise is formed within the coalition that doesn't give either group what it really wants, so "the little person" starts out with a handicap as perceived by its representing group, which brings us to the next potential problem with coalitions.

Coalitions are formed mostly to pool resources. Most concerned groups cannot afford to purchase lobbyists for their cause, so they go in with other groups. The danger is that the coalition becomes just one group or lobbyist in the eyes of the regulators and politicians it is trying to influence, even though the coalition may be comprised of anywhere from, say, two to a hundred groups of varying importance and membership in their respective communities. Having the presence of a small number of folks lobbying for coalitions is helpful, but they can still easily get lost among a bevy of high-paid and very influential lawyers and ex-politicians that the other parties use.

Don't get me wrong, I think coalitions are the best, and maybe only, reasonable way to go for the "little person." They are specially helpful at the beginning when a solid front for purpose and action can be developed using the coalition's research and communications resources. That can then become guidelines or principles for any groups or other coalitions that want to subsequently become involved. Once a platform is developed that outlines the guidelines and principles, then it also becomes easier for individuals to have an influence by directly contacting government officials.

An individual could (and should) call up a representative and say, "I just read the Sustainable Energy Coalition's principles for the direction that utility deregulation could be going, and I'd like to send you a copy and ask you to become an advocate for these principles." I know, I know, the "little guy" trying to get the politicians to work for them is very frustrating, and often fruitless. Except in one case. If lots of individuals do this, then the politicos may view a trend and then take that into consideration.

**Light Bulb On**

I just flashed on a great idea, so pardon my stream of consciousness here, I'll get back to the dereg stuff shortly. What if only once every two years each of us concerned about energy issues became lobbyists? I know that it would be tough to pull off and would take a significant sacrifice, but isn't it worth it to get some better movement in the direction of renewable energy?

Here's the idea. Take a one week vacation once every two years. Throw away the idea of spending big bucks going to Tahiti or driving to Yosemite, you can do that next time. Instead spend 4 days boning up on an energy issue that is important to you, including all the laws, current regulations, and potential for creating U.S. jobs, then iron your suit and head off to DC for 3 days of flight and prearranged meetings with your Congresspersons and Senators and their appropriate staff. There are even groups in D.C. and elsewhere that would be willing to help you with your boning up! While you're there, have a mini-vacation by visiting the Smithsonian and some of the other great museums in the area.

Friends, I think this could really work! Imagine if each representative had a meeting with a constituent from their own district about energy issues each and every week! I defy you to tell me that won't have an influence. Specially if the person comes back to their community and explains to the press and public exactly how the trip went and the representative reacted!

OK, more on that in the future, but back to the issue at hand. A coalition has been formed that has had around 30 organizations sign on to its newly released "Federal Agenda for Electric-Industry Restructuring." Quoting from the Agenda:

"In its combined economic, equity, and environmental significance, the electric industry has few rivals. Congress is considering proposals that would fundamentally restructure the entire industry. Such proposals could compound existing problems and create new ones. Therefore, any such legislation must lead to a cleaner environment as well as lower electricity bills for all consumers. To ensure that electric industry restructuring yields real benefits to both consumers and the environment, we unite behind a common agenda."

The Agenda summary includes the following 8 points. See access for info on how to get the full Agenda, which is fleshed out pretty well.

1. Require all power generation to face full and fair competition.

2. Ensure universal, reliable, and quality service through strong consumer rights and protections.

3. Expand the use of energy efficiency and renewable energy.

4. Ensure fair allocation of the benefits and costs of electric restructuring.

5. Require that the restructuring be designed to produce an industry that operates in a manner compatible with achieving national environmental and public health objectives.

6. Acknowledge and strengthen appropriate state and regional regulatory authority.

7. Require electricity suppliers to disclose to consumers important information regarding their electricity purchases.

8. Assure environmental mitigation and consumer protection in operation of facilities used by federal Power Marketing Administrations.

**The Plot Thickens**

A new bill was introduced in the House called the Electronic Consumers' Power to Choose Act of 1997. H.R. 655 was introduced by Congressman Schaeffer and has been referred to the Committee on Commerce. This bill is in its early stages, and much will happen to it as the armies of lobbyists have their influence on key committee members.

Fortunately, Congressman Schaeffer is a strong advocate for renewable energy. We'll keep you posted on how it goes. Schaeffer's office is also coordinating Congress' second annual renewable energy fair, scheduled for mid April. We hope to have Home Power represented at the fair.

**Access**

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"Federal Agenda for Electricity-Industry Restructuring"
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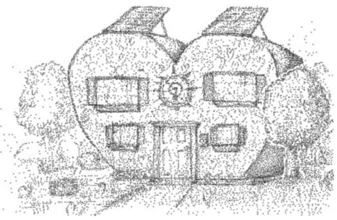
# Home & Heart



Kathleen Jarschke-Schultze

Many readers have been curious about how a bread machine works on a renewable energy system. I know that my friends and family who live on grid love the ease and taste of bread machine loaves. After receiving a bread machine for Christmas from my mother I dove in.

**Christmas 1996**
My mother shipped the machine by UPS in its own box. I knew that was what I was getting so it was no surprise. I put it under the tree and waited for the holiday to open it. Packaging was quite adequate. There were no problems opening it and it came out of the box in perfect shape.

The bread machine I got was the West Bend Automatic model. This is the model all my bread machine owning family members have and they all have had only good experiences with it. Since the manufacturer knows you will want to start right away, they send a packaged mix and yeast right inside the machine. With a minimum reading of the instructions you can get right to baking. The docs then recommend you read more extensively as your machine bakes that first loaf.

**Documentation**
The instruction pamphlet that came with the machine is quite informative on all aspects of machine use. I particularly like the extensive troubleshooting guide. Probably because I need that input. Myna, my compadre, has an earlier West Bend model and her instruction book had a lot more recipes than mine.

On December 29th, I baked my first machine loaf of bread. I read the “Important Safeguards” with some trepidation. Most warnings were the typical don’ts. Don’t shock yourself, don’t burn yourself, don’t abuse the appliance in obvious ways, etc. However, the one that concerned me most was as follows: “Your West Bend. Bread & Dough Maker was designed for use with 120 volt, 60 hz electrical service ONLY. Use of our bread & dough maker with a converter or transformer will destroy the electronic control and will void your warranty.”

“Yikes,” I said to Bob-O, “It’s not going to work!” He assured me that they probably meant any type of square or modified sine wave power. We have the Trace SW4024, which produces full sine wave, so this was a moot point. All testing was done using this inverter. That first loaf turned out great.

**New Year’s 1997**
On New Year’s Day our little creek was very big, very brown, and very fast. We could no longer see our hydro pipe. We had saved the microhydro machine two days earlier when the water rose to cover the bottom half of the machine.

Bob-O and I were both in Yreka that Monday evening. I got home first. When I got to the (usually) Dry Gulch culvert and it was 15 feet wide of fast brown water I counted to three and drove where I knew the road bed was. As soon as I got home I went down into the creek to get the hydro unit up out of the water. It was and had been raining heavily for the last 10 hours.

The water was just coming over the bottom of the unit. I tried to get the hoses off but I couldn’t wrestle them off. I called Bob-O on the two meter radio to see where he was. He said he would be home in about twenty minutes. He called when he got to Dry Gulch. It was about twenty feet wide at that point. I met him down at the creek.

We waded into the cold water. It was over the tops of our gum boots, fast and brown with sticks and debris hitting our legs. The top of the hydro machine still stuck above the water. Bob-O turned off the water valves, something I had forgotten to try in my attempt. The flashlight was on top of a rock about the height of my chest giving us light, but not where we needed it. I tried to hold the machine out of the water while Bob-O unhooked the hoses. Two wires on the unit struck each other and sparked blue light. Smoke stung my nose. “Pay no attention to that,” Bob-O says to me, “Don’t worry about that.” Sure....

This is one of those times when I ask myself how did I get to this place and time? We put the unit on the rock by the flashlight. Before it was over the water was almost to the top of that rock. We lost big sections of pipe and were without hydro power for weeks waiting for the water to go down enough to wade in and do repairs. There was little sun and the only wind we got were gusts just before a storm. We had to run the generator. This is always painful for Bob-O. But it was special circumstances.

**Testing Resumed**
After the hydro system was repaired and on line again, I resumed testing the bread machine. The electrical measurements were taken with Bob-O’s Fluke 87 meter. This was awkward at times because it had to be on a day when Bob-O wasn’t going on a job where he

needed the Fluke. I ended up baking more loaves than I have data on.

The machine has the option of a 1 1/2 lb loaf or a 1 lb loaf so I always made the larger loaf. The cycle takes from 3 to 3 1/2 hrs depending on the cycle option you use (light, medium, dark or basic, specialty, or wheat). The peak watts varied between 660 and 672. The total watt-hrs were from 327 to 369. Average watts were from 103.2 to 125.

You can remove the dough at a certain point and form it into cinnamon rolls or buns or whatever and then bake it in your oven. This would of course use even less electricity. If you are not there when the bread is done, the machine automatically keeps it warm for 3 hours. This would use more electricity.

Not all the loaves turned out well. This was my fault, though. This is one thing I have learned about the bread machine. YOU HAVE TO FOLLOW THE MEASUREMENTS EXACTLY. My mother warned me about this and sent a set of measuring spoons and cups with the machine because she knew I didn't have any. Every time I measured ingredients exactly, the loaf turned out fine. Whenever I fudged the measurements it turned out badly.

**Bread Machine Accouterment**

I found a great book called "The Bread Machine Magic Book of Helpful Hints" by Linda Rehberg and Lois Conway. This book has a buyer's guide for many types of bread machines. It has pages of troubleshooting data and many recipes. I do recommend it heartily. In fact, I would buy the book and read it before I picked a bread machine model to buy. Be sure to get the updated and revised edition.

**Conclusion**

In my family we all like the fresh baked bread the machine makes possible on a regular basis. The model I have is about $89 retail and worth it to me.

**Access**

Kathleen Jarschke-Schultze is eating home-baked jalapeño cheese bread at her home in northern-most California, c/o Home Power Magazine, POB 520, Ashland, OR 97520 • 916-475-0830
E-Mail: kathleen.jarschke-schultze@homepower.org or kjs@snowcrest.net

# Writing for
# *Home Power*
# Magazine

*Home Power* is a user's technical journal. We specialize in hands-on, practical information about small scale, renewable energy systems. We try to present technical material in an easy to understand and easy to use format. Here are some guidelines for getting your RE experiences printed in *Home Power*.

**Informational Content**
Please include all the details! Be specific! We are more interested in ispecific information than in general information. Write from your direct experience—*Home Power* is hands-on! Articles must be detailed enough so that our readers can actually use the information.

**Article Style and Length**
*Home Power* articles can be between 350 and 5,000 words. Length depends what you have to say. Say it in as few words as possible. We prefer simple declarative sentences. Sentences which are short (less than fifteen words) and to the point. We like the generous use of Sub-Headings to organize the information. We highly recommend writing from within an outline. Check out articles printed in *Home Power*. After you've studied a few, you will get the feeling of our style. System articles must contain a schematic showing all wiring, a load table, and a cost table. Please send a double spaced, typewritten copy if possible. If not, please print.

**Editing**
We reserve the right to edit all articles for accuracy, length, and basic English. We will try to do the minimum editing possible. You can help by keeping your sentences short and simple. We get over three times more articles submitted than we can print. The most useful, specific, and organized get published first.

**Photographs**
We can work from any photographic color or B/W, print, slide, or negative. We prefer 4 inch by 6 inch color prints which have no fingerprints or scratches. Do not write on the back of your photographs. Please provide a caption for each photo.

**Line Art**
We can work from your camera-ready art. We can scan your art into our computers, or redraw it via computer. We usually redraw art from the author's rough sketches. If you wish to submit, via computer file, a schematic or other line art, please call us via telephone.

**Got a Computer?**
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You can send your article via modem to either the HPBBS at 707-822-8640 or via Internet as an enclosed TEXT file(s). HPBBS address is: Richard Perez

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It is wise to call, via voice, ahead of electronic file submission. This is particularly true concerning graphics files. There are many, many ducks and they all need to be in a row....

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# HAPPENINGS

**CANADA**
The 8th Canadian Hydrogen Workshop by the Canadian Hydrogen Association, May 25-27, Toronto Canada. "Towards Hydrogen Commercialization." Contact Steve Mehta, CHA, 5 King's College Rd., Toronto, Ontario, Canada M5S 1A4 • 416-978-2551 • FAX 416-978-0787.

2nd Annual Great Electric Car Contest, Saturday, May 24. Hosted by the Queen's University Faculty of Education in Kingston, Ontario. High school students to design and build a single seat electric vehicle, powered by a 12 Volt automotive battery and capable of traveling a maximum distance within a 2 hour time limit. At least 20 vehicles will be competing. Personal and corporate sponsorships needed. Contact: Brian Perkins 613-545-6262 • E-Mail: perkinsb@educ.queensu.ca

Microhydro Courses. In conjunction with BC Community Colleges & the Solar Energy Society of Canada, taught by Robert Mathews. Selkirk College in Nelson April 5-6 Phone 250-352-6601, Okanagan Univ. College in Salmon Arm May 3-4 Phone 250-804-8888, SESCI - UBC Campus in Vancouver Phone 250-679-8589.

The "Alberta Sustainable House" is open for public viewing every Saturday 1:00-4:00 PM free of charge. The project emphasizes cold-climate features/products based on the founding principles of occupant health, environmental foresight, resource conservation, AE, recycling, low embodied energy, self-sufficiency, and appropriate technology. Already in place: R17 windows, multi-purpose masonry heater, solar hot water, greywater heat exchangers, LED and electroluminescent lighting, solar cookers, and others. Under development: hydrogen fuel cells, Stirling co-generator, Tesla bladeless steam turbine, and others. Contact: Jorg Ostrowski, Autonomous & Sustainable Housing Inc/Alternative & Conservation Energies Inc, 9211 Scurfield Dr NW, Calgary Alberta T3L 1V9, Canada • 403-239-1882 • Fax: 403-547-2671

The Institute for Bioregional Studies was founded to demonstrate and teach recent ecologically-oriented, scientific, social and technological achievements that move us toward ecological, healthy, interdependent and self-reliant communities. For info: IBS, 449 University Ave, Charlottetown, Prince Edward Island C1A 8K3, Canada • 902-892-9578.

23rd Annual Conference of the Solar Energy Society of Canada, June 5–7, 1997, Vancouver, British Columbia. Topics will include: housing & building, solar thermal, PV, other sustainable technologies, economics, policy & business, transportation & education. For more info:Solar Energy Society of Canada, Inc. (SESCI), 2nd Floor, 2415 Holly Ln., Ottawa, Ontario K1V 7P2, Canada • 613-523-0974 • 613-736-8938 • E-Mail: solar@worldlink.ca • Web: www.newenergy.org/newenergy/sesci.html

**GREECE**
1st European Conference on Clean Cars & 1st Hellenic ECO Rally, May 16-18, Athens Greece • Fax +301 772-2028

**INDONESIA**
The Asia-Pacific Initiative for Renewable Energy and Energy Efficiency Event '97, October 14–16, Jakarta Convention Center. The largest collection of RE and energy efficiency companies in Asia. Includes top speakers and focus on marketing strategies, project financing, policies and incentives for implementation in the Asia-Pacific region. For info: Alternative Development Asia Limited, 5/F 3 Wood Rd, Wanchai, Hong Kong • +852 2574 9133 • Fax: +852 2574 1997 • E-Mail: altdev@hk.super.net • Web: www.hk.super.net/~altdev/

**SPAIN**
14th European Photovoltaic Solar Energy Conference and Exhibition, Palacio de Congresos in Barcelona (Catalunya), Spain June 30th to July 4th. Contact: 20 WIP, Sylvensteinstr. 2, D-81369 M FCnchen, Germany • +49 89 720 1232 • Fax +49 89 720 1291 • E-Mail: renewables@mail.tnet.de • Web: www.wip.tnet.de

**UNITED KINGDOM**
Weekend Workshops! Build a wind generator, PV, water heating system or any alternative technology project. Work with others of varying ability in a well equipped workshop. By Robert Keyes GW4IED, of Keystone Systems. Held in Newport close to the M4 J25, Saturday 12–6, Sunday 9–4 with hotel & B/B close by, hard standing suitable for caravans available on site. Through 1997. Contact:Tel/fax 01633 280958.

**NATIONAL**
Solar Energy & Systems, a college credit course by Mojave Community College. Covers fundamentals of RE for the individual home owner or small villages. Taught on the Internet using the latest technology. Includes weekly assignments for students to review various text books, videos, WWW pages, a weekly chat room, and email questions and answers from students. Tuition $100 plus $10 registration. Contact Don Timpson, 800-678-3992

Online Energy Info Resources—Information on energy efficiency or renewable energy technologies. US Department of Energy (DOE) has two sources of online access. The Energy Efficiency and Renewable Energy Clearinghouse (EREC) BBS Online Service offers users free access to text files, share and freeware programs and utilities, and a free publication ordering system. The service is accessible via the Web at erecbbs.nciinc.com or by modem at 800-273-2955. The Energy Efficiency and Renewable Energy Network (EREN) is also accessible on the Web at www.eren.doe.gov and provides links to hundreds of government and private internet sites. EREN also offers an "Ask an Energy Expert" online form that allows users to E-Mail their questions directly to specialists at EREC. For more information: 800-363-3732.

American Hydrogen Association, national headquarters, 216 South Clark Dr. #103, Tempe, AZ 85281 • 602-921-0433 • Fax: 602-967-6601 • E-Mail: aha@getnet.com • "Prosperity Without Pollution" Web site: www.getnet.com/charity/aha

Energy Efficiency and Renewable Energy Clearinghouse (EREC) offers free info on Clean Energy for a Competitive America! Learn to use energy more efficiently. The DOE offers FREE info on windows, lighting, insulation and tips for energy savers. Get the fuel economy ratings of the new 1997 model cars! The DOE and the Environmental Protection Agency jointly produce a Free publication The 1997 Fuel Economy Guide (SD397). Also available: Heating the Home (FS236) info on improving the efficiency of your electric, gas or oil heating system. To obtain copy contact EREC: 800-363-3732 • PO Box 3048, Merrifield, VA 22116 • E-Mail: energyinfo@delphi.com • TDD: 800-273-2957 • BBS at 800-273-2955 • Web: www.eren.doe.gov

Visit American Wind Energy Association home page on the World Wide Web: www.igc.apc.org/awea. Visitors to AWEA's home page can obtain information about the US wind energy industry, AWEA membership, small turbine use, and much more.

Last year's American Solar Energy Society & USDOE's & Interstate Renewable Energy Council National Tour of Solar Homes was a great success. To participate in the 1997 event (October 18) contact: American Solar Energy Society, 2400 Central Ave #G-1, Boulder, CO 80301 • phone 303-443-3130 • Web: www.ases.org/solar/

**NORTHEAST UNITED STATES**
Ninth Annual NESEA American Tour de Sol, US Road Rally Championship for Electric Vehicles, May 17–24, 1997, Waterbury, CT to Portland, ME. Contact: NESEA, 50 Miles St, Greenfield, MA 01301 • 413-774-6051 • Fax: 413-774-6053.

**ARIZONA**
15th Tucson Solar Potluck and Exhibition by Citizens for Solar, May 10th, sunup to sundown at Catalina State Park. Camping available Fri. & Sat. See solar cooking devices and bring your own. Also PV, wind and other RE technologies. POTLUCK! Children's events, music, hiking, fun. Educational event open to the public. $4 per carload park entry fee. For info: Ed Eaton, 970-963-8855 • E-Mail: eaton@sopris.net • Or Toby Schnieder, 520-292-9020

Solar energy for environmental education! Come join Solar Energy International (SEI) in Flagstaff. PV design and installation workshop April 28th - May 3rd at Camp Colton Environmental Education Center, in the pines and aspens at 8800 feet ten miles from downtown Flagstaff. Thousands of school children spend one full week of their school year at the camp learning about our environment. Participants will install a PV system to power the camp lodge. Lodging included in the tuition. Four days of lecture and lab with two days of hands-on instruction. $500.00. For more info:Solar Energy International, PO Box 715, Carbondale, CO 81623 • 970-963-8855 • Fax: 970-963-8866 • E-Mail: sei@solarenergy.org

The State of Arizona is offering a tax credit for installation of all types of solar energy systems. A solar technician certified by the AZ Department of Commerce must be on each job site. For info contact ARI SEIA, 602-258-3422.

**ARKANSAS**

Sun Life is conducting “Third Saturday Seminars” on inexpensive building techniques. Focus is to teach home building from materials that can last a thousand years and cost less than conventional wood-framing. Hands-on all-day workshops. Contact: Loren, PO Box 453, Hot Springs, AR 71902.

**CALIFORNIA**

“Take Your Bedroom Off the Grid,” an intensive workshop to teach people they can get off the grid a little at a time. April 11-14, Arcata, CA. Attend any number of days, each builds on the previous. Culminates with a hands-on installation on a local home. $20-$65. Conducted by Johnny Weiss of SEI. Reservations for limited class size needed. Contact: Redwood Alliance, PO Box 293 Arcata, CA 95518 • 707-822-7884 • E-Mail: redwood.alliance@homepower.org • Web: www.igc.apc.org/redwood

Rising Sun Energy Center presents ongoing Solar Energy Classes including electricity, water heating, cooking, and a kids’ day. Contact for schedule and info: PO Box 2874, Santa Cruz, CA 95063 • 408-423-8749 • E-Mail: sunrise@cruzio.com • Web: www.cruzio.com/~solar

Offline will have an Introductory Residential PV Design workshop on Oct. 18 for beginners. Costs $35. Enrollment limited. Advanced Hands-On will be June 14 and 15. The Advanced will be held at Sun Mountain Tollhouse, CA. Participants in this workshop will upgrade the existing PV system at Sun Mountain. We will install an APT Powercenter & a Trace SW4024 and re-wire the existing modules and powerhouse to current NEC standards. This workshop is appropriate for the person who knows they will install their own system. Costs $250 includes lodging. Enrollment limited to 10, so enroll early. Contact: 209-877-7080 • Email: ofln@aol.com. The Advanced workshop is a benefit for and part of a Straw Bale project at Sun Mountain. If interested in Straw Bale construction, call George Ballis at 209 855 3710.

Institute for Solar Living offers ongoing workshops on a variety of subjects. Call Real Goods, 800-762-7325.

**COLORADO**

Solar Energy International (SEI) offers hands-on workshops on the practical use of solar, wind, and water power. The Renewable Energy Education Program (REEP) features one and two week sessions, PV Design & Installation, Advanced PV, Wind Power, Micro-hydro, Solar Cooking, Solar Home Design, Cob & Natural Building, Straw-Bale Construction and Adobe/Rammed Earth. Experienced instructors and industry representatives. Learn in classroom, laboratory and through field work. The workshops are for owner-builders, industry technicians, business owners, career seekers, and international development workers. The workshops may be taken individually or as a comprehensive program. $450 per week. SEI is a non-profit educational organization dedicated to furthering the practical use of RE technology. Contact: SEI, PO Box 715, Carbondale, CO 81623 • 970-963-8855 • Fax 970-963-8866 • E-Mail: sei@solarenergy.org

SEI with Richard & Karen Perez are offering a special workshop, “Successful Solar Businesses” May 29-30 in Carbondale, CO. How to establish and operate a successful solar business. Topics include career choices, RE industry perspective, marketing strategies, product sales and services, optimizing computer systems, and legal and tax issues. $200. Contact SEI, see above.

Visit the new National Wind Technology Center operated by the National Renewable Energy Laboratory, just outside of Golden, CO. The facilities assist wind turbine designers and manufacturers with development and fine-tuning and include computer modeling and test pads. Call in advance, 303-384-6900 • Fax: 303-384-6901.

**CONNECTICUT**

Building Energy ‘97: Insuring a Sustainable Future; Two Conferences, Workshops and a Trade Show. NESEA’s Quality Building Conference and NESEA’s RENEW ‘97 will bring together experts and decision makers from the advanced building and renewable energy industries to describe how quality construction practice, emerging technologies and global market opportunities will shape communities of the future.

Renew ‘97 and Building Energy ‘97. Building Energy ‘97,a launching point for sustainable development in the next millennium. Green buildings and RE. Architects and builders, code officials, land-use planners, and landscape architects will discuss how communities can work together to make sustainable development standard practice. Insurance and financial experts will participate in the analysis of RE and sustainable building not only as strategies for loss mitigation, but as the key investment opportunity for “insuring the future.” Renew ‘97 will focus on the latest in renewable technologies in real market applications, highlighting a niche in an evolving utility environment and a booming global marketplace. Contact: NESEA, 50 Miles St, Greenfield, MA 01301-93212 • 413-774-6051 • Fax: 413-774-6053.

**FLORIDA**

First South Florida Sustainable Building Conference and Exhibition, April 10–12. For building professionals, regulators, researchers and users. Workshops, seminars and exhibits covering sustainability issues in the planning, design, construction, operation and demolition/or recycling of commercial and residential buildings. For info: 305-375-1150 • Fax: 305-375-1157.

14th International Electric Vehicle Symposium, December 15–17, Walt Disney World Dolphin, Orlando, FL. Contact: Pan Turner, EVS-14 Symposium Manager, c/o First Option, 15 N Ellsworth Ave Ste 202, San Mateo, CA 94401 • 415-548-0311 • Fax: 415-548-9764 • E-Mail: firstopt@aol.com

**GEORGIA**

Photovoltaic Technology and Applications, April 15–17, Atlanta, GA. Examines PV technologies and applications from basic properties of sunlight and PV conversion to the design and modeling of PV systems, cost considerations and building integration. Students will visit and study the Georgia Tech Olympic Aquatic Center which features a large roof-mounted PV system. Conducted by: Georgia Tech Continuing Education. Program. $975. Contact: Department of Continuing Education, Georgia Institute of Technology, Atlanta, GA 30332-0385 • 404-894-2547 • E-Mail: conted@gatech.edu • Web: www.conted.gatech.edu

Photovoltaic Design and Installation! Solar Energy International (SEI) announces a hands-on workshop in Atlanta, GA, April 7–12, at the Southface Energy and Environmental Resource Center. Held in cooperation with Southface Energy Institute of Atlanta, a non-profit performing research, education, and consulting on energy and environmental technologies. $500. Topics include: solar site analysis, system sizing, PV modules, controllers, batteries, inverters and appliances, demonstrations, lab exercises and hands-on installation. No prior experience or training is necessary. Contact: Solar Energy International, PO Box 715, Carbondale, CO 81623 • 970-963-8855 • Fax: 970-963-8866 • E-Mail: sei@solarenergy.org

**MASSACHUSETTS**

NESEA is converting its headquarters into a showcase of environmentally responsive building. Members are converting a historic railroad hub into a working demonstration of a healthy, daylit, office building flanked by a park which celebrates transportation history while demonstrating principles of urban ecology. Opportunities for involvement: Saturdays at NESEA: A volunteer program through which construction novices learn green building tricks of the trades working with professionals. Major transformations of the building and park will be undertaken as “barn-raisings.” Contact. NESEA, 50 Miles St, Greenfield, MA 01301 • 413-774-6051 • Fax: 413-774-6053.

**MICHIGAN**

EnV’97 Environmental Vehicles Conference & Expo, April 7–10, Detroit, MI. Contact: 810-355-2910 • Fax: 810-355-1492

**MISSOURI**

The Missouri Renewable Energy Association is a non-profit educational organization, promoting energy sensible technologies as a solution to global environmental pollution. Improved energy efficiency. water conservation, recycling, and composting are just a few of the topics on our agenda. We encourage local government, businesses, schools, and individuals to become involved by joining the MO.REA today. Contact Ray Wathswski, PO Box 104582, Jefferson City, MO 65110 • 573-634-5051

**MONTANA**

Life Skills Workshops offered by Sage Mt. Center. Workshops include Making Log Furniture May 17 & Aug 16, Solar Electricity June 21 & Sept. 13, Strawbale Construction July 12, Cordwood Construction July 26, and Earth Friendly Home Building Aug. 2. All in-depth and hands-on. $45. Contact: Christopher Borton or

Linda Welsh, Sage Mt. Center, 79 Sage Mountain Trail, Whitehall, MT 59759 • 406-491-0954

**NEW MEXICO**
New Mexico Solar Energy Association's 25th Annual Life Technics Conference & 11th Peter VanDresser Workshop, October 3-5, Ghost Ranch Conference Center, Abiqui, NM. A solar & sustainable village conference. $45 for non-members, late fee after Aug. 22. Contact: NMSEA, PO Box 8507, Santa Fe, NM 87504 • 505-776-2012 • E-Mail: ksolar@laplaza.org

**NEW YORK**
The New York State Electric Auto Association (NYSEAA) is dedicated to sharing current electric vehicle technology. Monthly meetings. For date and location call Joan, 716-889-9516

Volunteers needed for Seedcorn's 4th Alternative Energy Fair & Home Tours. Saturday, April 26, in Potsdam, NY (3 hours north of Syracuse, near Cornwall, Ontario). Tours of AE homes on May 3rd & 4th. Contact Chelle, PO Box 5055, Potsdam, NY 13676 • 315-265-4619 • Fax: 315-268-1229 • E-Mail: ewb@herd.org.

Earth's Pulse: an Intercontinental Convergence. Caring for the planet and her children by sharing knowledge. Aug 18-24, Brushwood Folk Center, Sherman, NY. Demonstrations, workshops, discussion groups, guest speakers, music, earth ceremonies, and more. A benefit for Eco-Educational Youth Camp. Contact: Don Mackenzie, 4700-A8 Babcock St. NE Drawer 197, Palm Bay, FL 32905 • 800-759-8888 ext. 3211104 (national pager) • E-Mail: EPIC1997@aol.com.

**NORTH CAROLINA**
Wind Power Hands-on Workshop, April 7–12, 1997. Learn to design and install wind electric generator systems. Hands-on experience working with full-size wind machines. Install a home power wind system from start to finish with teacher Mick Sagrillo. Contact: Lyn, Solar Village Institute, PO Box 14, Saxapahaw, NC 27340 • 910-376-9530.

**OHIO**
The Great Lakes Electric Auto Association's mission is to contribute to the freeing of the US automobile market from dependency on petroleum through advancements in electric and hybrid/electric technology. For more info: Larry Dussault, GLEAA, 568 Braxton Pl. E, Westerville, OH 43081-3019 • 800-GLEAA-44 • 614-899-6263 • Fax: 614-899-1717 • E-Mail: DUSSAULT@delphi.com

Solar and wind classes at rural solar and wind powered home with utility back-up. Maximum 12 students. Advance register. $45.00, $50 per couple, lunch provided. Class #1: technical info, system design, system sizing, and NEC compliance, etc. Students will see equipment in use. Every 2nd Saturday of each month.Contact: Solar Creations, 2189 SR 511 S, Perrysville, OH 44864-9537 • 419-368-4252.

**OREGON**
APROVECHO RESEARCH CENTER is a non-profit educational institute on forty acres nestled in the forest of Oregon. Internship programs March 1, June 1 and September 1. Also, a six week winter internship in Baja, Mexico which focuses on studying and researching appropriate technology applications, learning Spanish, teaching in a grade school, and working in fruit orchards and gardens. Contact: Internship Coordinator, Aprovecho Research Center, 80574 Hazelton Rd., Cottage Grove, OR 97424 • 541-942-8198.

The Third Annual HOPES Eco-Design Arts Conference, April 11–13, Eugene, OR. This year's theme is Cultivating Communities and Helping Environments. Contact: HOPES, Lawrence Hall, 5249 University of Oregon, Eugene, Or 97403-5249 • 541-346-0719 • E-Mail: hopes@aaa.uoregon.edu • Web: gladstone.uoregon.edu:80/~ hopes/

The Lane Community College Energy Management Program is offering a PV design course for the Spring term. Content includes PV electricity basics, modules, batteries, controllers, inverters, lighting, appliances, and installation guidelines. Includes a tour of PV installations and culminates in a design project, David Parker, Instructor. Contact: Roger Ebbage, LCC, 541-747-4501 ext. 2451 • out of area 800-769-9687 • E-Mail: ebbager@lanecc.edu • Web: lanecc.edu:1080/webpages/lcc/science/home.htm

**UTAH**
Timber Frame, Strawbale, and Straw-clay Workshop, April 16-20. Led by Robert Laporte. Raise the walls on a community building, covers earth plastering and earth floors, as well. $525 for 5 days, $255 for 2 days. Contact: Kevin Holladay, 326 Staab St., Santa Fe, NM 87501 • 505-986-5847 • E-Mail: k_holladay@gmfsh.state.nm.us

**VERMONT**
Free PV Workshops for beginners to experienced by David Palumbo of Independent Power & Light, first Saturday of most months. Interest will determine which of the following topics will be discussed: site selection, PV modules, batteries, safety, charge controllers, inverters, DC lighting, balance of system components, system monitoring and maintenance, water topics, snow topics, ponds, living in cold climates, living with our woods, heating with wood, and root cellars. Contact: David Palumbo, RR1 Box 3054, Hyde Park, VT 05655 • Voice or Fax 802-888-7194.

PV Home Electric Systems Seminar and Workshops by Sunnyside Solar. Beginners programs April 12 and August 2. Cost $95 each or $175 for two persons. Advanced programs geared toward contractors, carpenters, electricians, plumbers, and architects June 7-8 and Sept. 20-21. For info and reservations contact: Carol Levin, RD4 Box 808, Brattleboro, VT 05301 • 802-257-1482 • Fax: 802-254-4670 • E-Mail: sunnysde@sover.net

**WASHINGTON STATE**
School of Natural Living is offering a series of workshops. Earthen Plastering June 14-20, Strawbale Building June 23-29, Cob Construction July 16-22, Timber Framing Aug. 15-22. $450 per week or $195 weekend only, includes camping, lunch, and use of campus facilities. Contact: 1356 Janicki Rd., Sedro-Woolley, WA 98284 • 360-856-5482 or 360-854-0413 • E-Mail:jkelley@ncia.com

Renewable Energy Fair & Solstice Celebration presented by The River Farm Community Land Trust, June 20-21. 50 classes, including hands-on workshops on PV, hydro, batteries, inverters, charge controllers, energy conservation, and off grid living. Includes info and demos on wind power, car conversion, bio-fuels, fuel cells, and product literature. Admission $75 before May 20 and $90 later includes camping, food, workshops, classes, and entertainment. Contact: The River Farm, c/o Renewable Energy Fair, 3231 Hillside Rd., Van Zandt, WA 98244 • 360-592-2716 ext. 4.

**WASHINGTON, DC**
SOLAR 97 American Solar Energy Society Conference. In conjunction with Soltech 97. For info: ASES 2400 Central Ave Suite G1, Boulder, CO 80301 • 303-443-3130 • E-Mail: ases@ases.org • Web: www.ases.org/solar.

Solar Energy Forum, April 25–30, Washington, DC. The combined annual events of: American Institute of Architects, American Society of Mechanical Engineers, American Solar Energy Society, Interstate Renewable Energy Council, Solar Energy Industries Assoc., Utility Photovoltaic Group, and the US DOE. Contact: Michelle Birkenstock, SEIA, 202-383-2620 • Fax: 202-383-2670 or Erin O'Donnell, UPVG, 202-857-0898 • Fax: 202-223-5537.

**WISCONSIN**
The Midwest Renewable Energy Association Spring Workshop Schedule. Introduction to Renewables April 5 • Basic Photovoltaics April 6 • Advanced Photovoltaics April 25–27 • Utility Intertie Wind Systems May 17–18 • A Day in the Dirt: Hands-on Experience with Earthen Floors May 17. Pre-Energy Fair Workshops: Off-Grid Wind Systems June 6–8 • Utility Intertie Wind Systems June 13–15 • Hands-On Photovoltaic Systems June 10–13 & 16–18. Call MREA for cost, locations, instructors and further workshop descriptions. Membership and participation in the MREA are open and welcome to all. Significant others may attend with you for 1/2 price. Contact: MREA, PO Box 249, Amherst, WI 54406 • 715-824-5166 • Fax: 715-824-5399

8th Annual Midwest Renewable Energy Fair, June 20-22, Portage County Fairgrounds, Amherst, WI. Workshops, speakers, exhibits, and demonstrations on RE and energy efficiency for children, educators, and the general public. Includes bus tour of RE homes, on site model home tours, food and entertainment. See above for pre-fair workshops and contact info.

Adult Solar Sprint and Junior Solar Sprint, at the Midwest Renewable Energy Fair on June 21. Sponsored by the Midwest Renewable Energy Association, Home Power Magazine and The University of Dubuque. For rules, entry, and kits contact: John Root, University of Dubuque Environmental Policy Dept., 2000 University Ave., Dubuque, IA 52001 • 319-589-3320 • E-Mail: PVperson@aol.com

the Wizard speaks

**Surf's Up**
Here are some web sites that you might find interesting. Each address should be prefaced by http://

**Energy Related Sites**

Home Power Magazine: www.homepower.com

Institute for New Energy: www.padrak.com/ine

Academy for New Energy: www.acad4newenergy.com

Cold Fusion Times: world.std.com/~mica/cft.html

Keely Net BBS: www.keelynet.com

Planetary Association for Clean Energy: energie.keng.de/~pace

Electrifying Times: www.teleport.com/~etimes

Infinite Energy: www.mit.edu.8001/people/rei/CFdir/CFhome.html

Infinite Energy: ourworld.compuserve.com/homepages/JedRothwell/

**Other Sites**

www.enterprise.com

www.lauralee.com

www.artbell.com

www.gbi.com/debshome/index.html

I compiled these from the radio and some magazines I've read. I haven't seen any myself since I don't have internet access. Good luck on your surfing expeditions.


**Natural**
**Home Book Project**
I'm an author in Washington state and I'm currently gathering information for a book about "natural" homes in the Pacific Northwest (Oregon, Washington, British Columbia). The book will highlight 20 or so homes that fit into the landscape, utilize native materials, experiment with renewable energies, adopt the region's creative spirit and history, and utilize and blend with nature by including greenspaces.

I suspect there are plenty of Home Power subscribers whose homes fit this bill. If you would like your home featured (note: I'd like to write about homeowners as well) or want to share information on this subject, I'd appreciate your input.

Thanks very much! Mike Page-English, 1703 W. Phillip St.,Oak Harbor, WA 98277 • 360-678-7435 (voice and fax) • E-Mail: lisamike@whidbey.net

*OK, Mike, here goes. Any readers who are interested, please contact Mike directly. Richard Perez*

**Renewal Notices**
In reference to the question about sub renewal notices in HP 57: What could be handier than having that info arrive with each issue? Every issue of HP includes within its pages a reminder to check the mailing label. I, for one, am awake and aware enough to check it. Saves paper and mailbox clutter. I'm sure the increased cost of sending renewal notices would soon be reflected in the subscription price; maybe we as readers can help keep it down through accepting a little responsibility.

A note to readers in reference to Electro-Biking by BIll Gerosa, Jr., HP 56: The American Bosch generator #10–1023 is listed in the Surplus Center 1996 Catalog (#269) as a DC motor, with applications as a generator—in case people are not finding it there. More important, when I ordered mine they had around 7000 (seven-thousand, yes) in stock. That was 1/21/97. The Best Always, Jim Wirth, Carlsbad, CA

*Well put JIm! We agree with you on the renewal issue but some readers do not. We have decided to give everyone a choice. The subscription form now has a new box. Yes, I want want to receive a renewal notice (one postcard only). No, I can check my label and save energy and trees. (A little guilt doesn't hurt!) We are hoping most folks will be willing to take the time to read their label. If not, we will send a single postcard, maybe using the tree free paper. While it will cost HP a little extra to send the cards, we hope that the resulting timely renewals will make up for it. Karen Perez*

**Heat Island**
Really enjoy the mag and all the effort put into this technology. I've lived here in "Heat Island" for 12 years and it still amazes me how few people take advantage of, at least, solar hot water assist. The initial cost of a system, $5–$7,000, scares most people. I found a used solar system, installed it myself six years ago and to this date may have $600 invested—$30 a month payback! Steven Kenston, Phoenix, AZ

*Good point to make, Steven. I have recently heard that solar domestic hot water systems have a full payback of between 2 to 7 years, depending on geographic location, whether the system was previously gas or electric, tax credits, utility rates, and amount of use. Everyone with a decent amount of sun should be looking at using solar DHW. Michael Welch*

**Vertical Axis Wind Gens**
In HP#56 Alfred Zirkel writes about his experiences building a renewable energy home. One problem he had was his original wind generator—the winds were so turbulent that the generator couldn't change directions fast enough to keep up, and therefore didn't generate much power. He replaced it with a smaller wind generator which worked better because it could turn faster into the wind.

Another solution to his problem would be a vertical-axis wind generator. They don't care which direction the wind is coming from, as long as it is blowing. I have seen pictures of them in an old book on alternative energy that described their basic operation, but haven't seen anything recently on them, even in HP's articles and advertisements (I've only been a subscriber for a year).

Does anyone make vertical axis gen's, commercially or otherwise? I would think that, with less weight /size at the top of the tower and a stationary generator (no wiper contacts) they would be simpler and cheaper to operate. But I assume from their absence in recent literature that there are some fairly significant problems with their operation—could you please tell me what they are?

Several people have written in the last year asking about info on fuel cells, I would like to add my voice to theirs. I am an electrician in the Navy, and am very interested in this. If you could point me in the direction of the info, I would be glad to write an article for HP with whatever I can scrape up.

I recently saw a blurb in Popular Mechanics where an aquarium used solar cells to generate power for a tank's filters and other equipment. Extra power from the solar array was diverted to an electrolysis plant to make hydrogen, which was stored. When the sun went down, the hydrogen was fed through a small fuel cell and electricity from the fuel cell was used to run the equipment.

This seems like an almost ideal setup to me. If the power companies won't let us use the grid to 'store' excess power (net metering), then the heck with 'em! Store it as hydrogen and use it ourselves! I know fuel cells are too expensive right now, but I can dream!

Great magazine! Here's my renewal payment and keep up the good work. Chris White, Charleston, SC

*Hello, Chris. One big problem with vertical axis wind generators is that they are usually located on the ground—where the wind is at a minimum speed. In order to get the swept area of the "propeller" large enough, they must be 20 or so feet tall. And this makes them hard to put on a high tower—which is where all wind turbines need to be. I know of no vertical axis turbines commercially made for the home-sized market. We have run fifteen articles on hydrogen to date. Check out the index in HP #53. We are going to be publishing more on hydrogen in the next few issues. The system you read about in Popular Mechanics sounds like the Schatz Hydrogen Project at Humboldt State in Arcata, California (see HP# 22, page 26). I'd love to be able to store surplus PV electricity as hydrogen, but the technology is*

*still much more expensive than batteries. Hydrogen is the ideal storage medium for the grid where the economy of scale makes it more cost effective. Imagine utility-scaled PV power plants making hydrogen for use at night. This hydrogen could be mixed with the natural gas in the pipelines already spanning the country. The mixture of hydrogen and natural gas could fuel utilities' natural gas turbines for both peak load shaving and night time use. Richard Perez*

**The Bleeding Edge**

As usual, I anxiously devoured your latest issue as soon as it arrived in the mail. I have been wanting to write to you to tell you what a wonderful job you have been doing in getting the good word out on renewable energy and all the practical information and good advice that appears in every issue.

I have been involved in the field of renewable energy since I put up a 1 kW windmill in October 1977. I had assembled a 120 Volt battery some ten years before for backup power and emergency lighting, and the windmill seemed a better way to charge the battery than purchasing commercial power. Unfortunately for me I was on the "bleeding edge" of a new technology, and found myself climbing my 50 foot tower in the rain, or worse, in the snow to make emergency repairs. Things improved with time, but I had learned the hard way that windmills were mechanical beasts that needed a lot of maintenance. The only relief that I got was from an individual in the next town that spent four times as much as I did and had twice the problems with his windmill.

Then came PV panels. I luckily located a source of used PVs just 50 miles away from my home. I was able to negotiate a good price on some used Solar Power Corporation 30 Watt modules. Soon I had both solar and wind power! Enough to power all my home's lighting needs and keep my 100 Ah battery charged.

I then began to research inverter technology and was very put off by the high prices/low efficiency of what was available. After trying to build a PWM inverter from scratch with an electrical engineer friend of mine for over a year, I finally gave up on a home brew approach to power conversion. The shoebox full of dead transistors and shorted SCRs once again reminded me of the price one pays to live on the "bleeding edge" of technology.

Then in 1982, I heard about a company in Wind Power Digest called Best Electrical Solutions for Tomorrow in Necedah, Wisconsin. They were a new company that had developed a low cost inverter for the fledging but now promising renewable energy marketplace. Utilizing my PV source, we were able to order a 6000 watt, 120 volt modified sine wave inverter. At the same time my brother-in-law told me about some batteries he had seen at a computer center where he was performing some service. He mentioned that he had seen similar batteries in my cellar to the computer center manager and was surprised that the manager replied "If your brother-in-law wants some more have him call me." After some negotiating, I was the proud owner of 180 cells of 450 Ah lead calcium batteries only four years old! Things were really starting to come together all right.

Rather than going on step-by-step as to what transpired over the next fourteen years, let me tell you what my system looks like today. My PV array consists of over two hundred Solar Power and Solarex 12 Volt panels. They are wired in groups of eleven panels in series mounted on my garage roof and on pressure treated 4 x 6's in my back yard. I generate over 7.5 kW of solar electricity at peak. It is stored in five separate 120 Volt battery banks that total 2600 Ah of capacity. They in turn feed that 6 kW Best inverter through a separate 100 Amp circuit breaker panel and a series of DPDT 30 Amp relays. The inverter powers almost all my electrical loads. The relays are energized with inverter power in such a way that if the inverter trips out for any reason, then all loads shift to utility power. I currently run two large chest freezers, two refrigerators, a 240 volt submersible water pump, microwave and other household appliances, two room air conditioners in summer, a workshop in my garage with power tools, and a 3.8 kW electric hot water heater when I have excess.

My latest addition to my RE system has been a 1992 Solectria Force electric car, which I purchased last May. I have put on over 3,000 solar powered miles getting to and from my job and performing local errands, like food shopping or picking up the kids at the ball field. It has a range of 50 miles per charge, but I rarely put on more than 30 miles in a busy day. It has a three phase ac propulsion system and such desirable features as automatic regen braking and an electric resistance heater for those cold New England winter mornings.

I should add that during the months of December and January I often have to supplement my solar power with some utility juice. I wish I didn't, but low sun angle, short days and snow covered panels make this a necessity in New England. The electric car has also added about three kwh a day to my total usage and cut my battery reserve down from five sunless days to about four. The solution probably lies in more panels. Since I have enough raw materials to build about forty 40 Watt panels (cells, glass, RTV, tabbing J boxes, gaskets and frames courtesy of a bid made to Solar Power when Exxon shut them down) I think that I am going to have plenty to do on all those dark evenings this winter. But that's another story...

Keep all those good issues coming and together maybe we can save the planet. Joseph F. Soboda, Jr, Rehoboth, MA

*Wow, Joseph, that's what I call a system! And kudos to you for your excellent and persistent hands-on approach. You are truly an RE pioneer. Keep us posted on how the module building went. We are always interested in printing Systems articles from our readers, and we think yours would be great. As a reminder to all, we like lots of photos and a system cost breakdown, and we need a clear schematic that we can turn into our popular skiz drawings. Additionally, but not necessary, we prefer to get the article text on disk or E-Mailed to us (ascii text only, no word processor formatting). Michael Welch*

*I'd like to second the request for an article about your system, Joseph. Yours is one of the few home power system that supports not only thermal loads, but also an electric vehicle! There are many of us trying to get where you are now—energy self-sufficiency. We can all learn from your experiences on the "bleeding edge." Richard Perez*

**Good Home Needed**

I am looking for a good home for a 10 inch vertical turbine pump with hollow shaft and a 20 hp, 550 v, 3 phase, induction motor motor. Ok as an induction generator at 480 volts (at reduced output). Would work well with 40 +/- feet head and 5 cfs flow. We estimate the output range to be 10 - 12 kw. We also have a unit with a thrust bearing to replace the motor to allow belting to another generator.

Terms: FREE, user pays shipping. We will provide a limited amount of free consulting to determine if the user has a feasible site. The person or group receiving it needs to have some serious technical/engineering background or help. If installed on a proper site with appropriate safety equipment, it could easily supply a small group of homes, a single larger facility, or sell excess power back to the utility with FERC licensing.

We operate a hydro-electric station with installed capacity of 420 kw. We intended set this pump up as a turbine for the fun of it but have decided that we will never get to it.

I imagine that Home Power gets a whole bunch of stuff from guys eager to sell you their wonder-gadgets which are guaranteed to supply unlimited power and cure the common cold for only $19.95.

But, I am not trying to sell anything!! Our company, Green Lake Waterpower, only sells electricity to the local utility and we have our hands full doing that. The problem is that I have no way of finding out who might be interested in adopting the unit described. There is no gimic. I would be happy to provide more details about the unit. David Kleinschmidt, Green Lake Waterpower Co., RR4 Box 134A, Ellsworth, ME 04605 • E-Mail: dklein@agate.net

*Wow, David, what an offer! HP readers interested in the large hydro can contact you directly. Sounds like an excellent opportunity for a community hydroelectric system. Richard Perez*

**Philippines**

I've been living in the Philippines for a number of years. Recently, I visited a local shopping center. One stall had a large number of used magazines on sale. I selected several that looked interesting, including a copy of Home Power #45, Feb/March 1995.

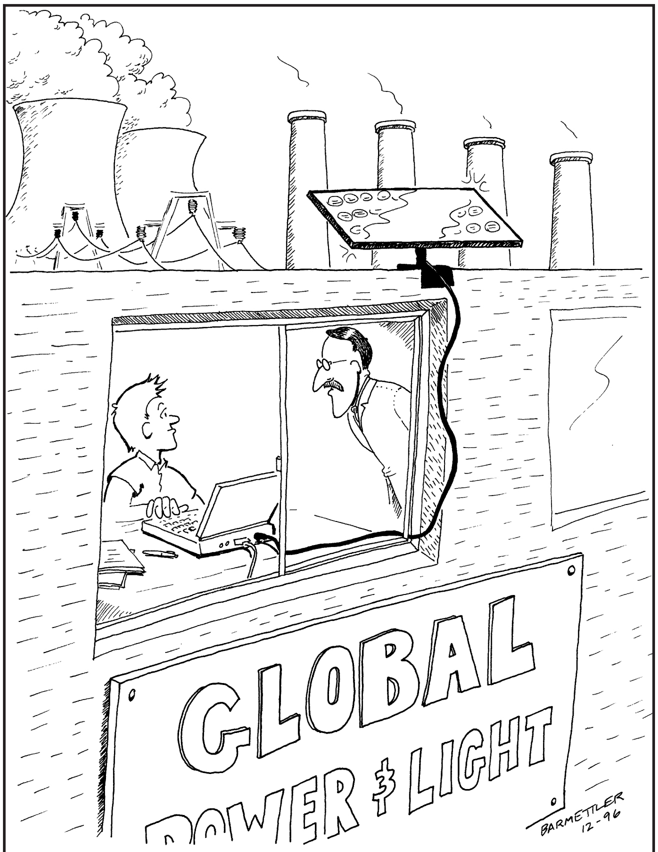
The articles and advertisements answer a lot of questions I've had about providing power in remote locations. We have plenty of them in this country.

I'd like to ask a question, one that may have been answered in one of your earlier issues. People here claim that it is possible to hook up an auto or truck alternator and a windmill to charge a bank of regular lead acid batteries. If you have any information on something like this I'd appreciate it. Willis H. Rohling, Philippines

*Hi Willis, glad you stumbled on us! We get this question a lot. Basically, you are interested in home-brewing a wind generator. We don't generally like to discourage folks from experimenting and home-brewing, but you need to realize that making a home built, durable and efficient, wind generator is difficult. First of all, the automotive alternators and generators are not suited for wind service—they want to run at high RPM while the wind genny runs at relatively low RPM. Most modern wind gennys are using permanent magnet alternators specifically wound for low RPM service. While I have seen several homebrew wind gennys using auto alternators, every one was a disappointment. While they produced some power, they didn't perform up to their maker's expectations. In terms of small scale, cost effective wind gennys, almost everyone is better off buying than homebrewing. Richard Perez*

**Electric Cooler**

Great magazine. I was wondering if anyone has done any experimenting with the iceless electric coolers? I have been running one on solar power for about seven months. I had to change the bridge rectifier to something a bit heavier and oil the motor that runs the fans regularly. I was thinking that it would be better to set up some type of thermostat to shut the thing off when it was at the desired temperature . Also I was thinking that it would be a good idea to superinsulate the cooler. I use this cooler camping and if it was more efficient I would not have to haul around a ton of batteries to run it. Oh ya, I have been running it continuously for 7 months. Any help you or your readers can provide would be a great help. Thanks, Richard Georgina, E-Mail: Rickferdg@x-net.net




"When I said we had to meet the challanges of the new deregulatory climate, this was not exactly what I had in mind...."

*Hello Richard, I have never used a CoolATron, but there are several in the neighborhood. These devices use Peltier Effect semiconductor junctions to move heat around. The fan just gets rid of the heat on the "hot" side of the junction.*

*The problems we have seen are: 1. These units are not made for continual or rugged use—hinge failures and cracked outer cases. 2. As you've discovered, they do not have enough insulation. 3. The maximum temperature differential is around 45 degrees F. This means it will not make ice in ambient temps above 80 degrees F.*

*I see no reason why building the unit into a permanent, insulated enclosure wouldn't work. It would function as a fine refrigerator. Remember to allow the hot air from the fan to escape the unit easily and quickly. Locate the unit with the fan blowing up into an exhaust flue. Some homebrew electronics or a factory made thermostat could provide temperature regulation and save energy. Keep me posted, sounds like an interesting project. Richard Perez*

**Bikes are Better**

Keep up the good work, great article on electric assisted bicycles. I currently drive an electric car when I am not riding my bicycle, but it still seems like such a waste of energy and space on the road and parking. You should do a review of Auto Free Times—call 707-826-7775.

I am very interested in grid intertie systems. I am hoping to hear about more successes in PG&E country. Jim Haagen-Smit, Newcastle, CA

*Hi Jim. I am very familiar with the Auto Free Times. Its parents, Alliance for a Paving Moratorium and the Fossil Fuels Policy Action Institute have their office space next door to Redwood Alliance, the non-profit I work with. The guys there are into some great stuff and are a good resource for road fighters and anti-car advocates. Home Power is a strong proponent of electric vehicles. It may be impossible to eliminate cars from the roads, so let's turn them into something as benign as can be. Even EVs that have to charge off the grid until solar stations are available are creating much less pollution than gas and diesel guzzlers. But, we strongly admire you and others that may be able to get by without cars by using bicycles and mass transportation. Michael Welch*

**Dismayed**

I'm increasingly dismayed at a magazine supposedly devoted to "hands-on home-made power" wasting so much space extolling the "virtues" of cooperation with government (read "terrorcrat." Governments can only rule with force!) sponsored energy programs. Show me any government program that can't be done cheaper or more efficiently by a free marketplace. There is no such thing as being half-free. It is immoral for us to use taxpayers' money (taken by force) for our personal gain. That is why most of us producing our power live beyond the power lines in the first place. Vertis M. Bream, Aspers, PA

*Hello, Vertis, I agree, governments exist by enslaving their constituents. Using taxpayer money for subsidizing the RE industry is not appropriate, but we're doing it now for oil, natural gas, and nuclear power industries. End all subsidies to all industries and we're home free. But, truly free marketplace means no regulations of monopolies and no environmental protections, back to the days of the robber baron. From a historical perspective, that worries me. Richard Perez*

**Air 303**

Thanks for the 1st complimentary issue. By calling around, using the ads in your magazine, I saved over $100.00 on my first wind generator (Air 303) and I am more than pleased with its performance. Happily Off-Grid, Robert Bailey, Tempe, AZ

*Well, Robert, the advertising in Home Power does indeed serve a useful purpose. What's the use of having all the info if you can't get your hands on the hardware? While there is substantial whining among some of our advertisers about price competition, I see this as a healthy sign that the RE industry is growing. Richard Perez*

**Thirst Quenching**

I have enjoyed your publication for several years and have finally gotten around to purchasing a subscription. I am a mechanical engineering student at the State University of New York at Buffalo. As a mechanical engineer, one of our core knowledge areas is energy system. Your publication quenches my deepening thirst for knowledge and applications of renewable energy systems. I am curious, though, about what job opportunities exist in this field. Paul Bock, Buffalo, NY

*Hey, Paul, if I were looking for a job in RE with an ME degree I would be sending resumes to: tracker makers, wind genny makers, pump makers, tower makers, and hydro makers. All these fields have jobs where an degree in mechanical engineering would pay off. Richard Perez*

**Snail Mail**

Due to the irregularities of Third World mail delivery, I just got my first issue (Aug/Sep 1996) now, at the end of January. Not that I'm complaining! On the contrary, I'm delighted—it's like seeing an old friend again.

Peace Corps life is treating me well. I'm living in a small, off-the-grid village 7,000 feet up in the mountains near the border with El Salvador. I never thought that a move from northern California to Central America would mean moving to a colder climate, but daytime temperatures here rarely rise above the 60s, and nights get down into the low-mid 40s!

I've made friends with a fellow US expatriot/Home Power subscriber who's here working on small scale energy projects. He's helping me to evaluate communities in my area for RE potential and I'm going to be supporting him in the coming months on a community micro-hydro project. Ironically, while my community uses burning sticks of pine for light and has no electronic communication with the rest of the world, there are high-voltage power lines passing right through the village. They could probably hook up the whole village to the grid for about US$5000 if they had it. Neighboring communities that are farther from power lines may be candidates for PV or wind projects. I'll keep you posted. Richard Engel, La Paz, Honduras

*Well, Richard, we're in the same boat here on Agate Flat. We've got high voltage power lines only 1/2 mile from us, but they just pass on through. Installing a substation is far too expensive and inefficient (since we would be a micro load and wouldn't hook up anyway). Many folks in rural areas get all the disadvantages of high voltage electric power transmission with no possibility of getting any of the advantages. Keep us posted on your projects in Honduras. Richard Perez*

**Read Your Label (or Check the Box)**

I really like your current renewal policy. A good compromise is the box you referred to on the subscription form. It will be interesting to see how many of those who can't remember to look at their mailing label (even with a humorous reminder inside the magazine somewhere) will remember to resubscribe even after a reminder. Good luck, Mark Heinlein, Bend, OR

*We'll see how it shakes out, Mark. I'm death on junk mail. Home Power does not sell its mailing list. You will receive no unsolicited mail because you have subscribed to Home Power. I feel like the flip side of this pact with our readers is helping us keep your subscription current by checking your mailing label. In some cases, such as an Adopt A Library sub, this is impossible. We stand ready to mail anyone a sub expiration notice if they request it. The rest of us will keep on checking that mailing label! Richard Perez*

**EVs, and He Reads His Label**

I just received my latest "Last Issue"—damaged by the Post Office again. Renewal subscription check enclosed.

I also received some merchandise from J.C. Whitney and lo and behold look at the package stuffing: an article on, dare I say, the "First" (and probably last) mass produced electric vehicle. (ed. note: a Chicago Tribune clipping on a new GM EV1 car was enclosed.)

I don't dare start marking up the article as you wouldn't be able to read it. I also better send it before my "red hot anger" ignites it! (Not quite) But, it seems to me, with all the wasted R&D and production dollars, something a little better would have emerged on the scene. It really seems like it's an extremely expensive lemon purposefully designed to fail.

And to think that Prof. Billings and his students' hydrogen/fuel cell demo package in that used Post Office delivery vehicle shown at SEER in Willits, California four years ago could outperform and especially outdistance it, makes this "new" vehicle pathetic!

I'm sure you also noted the Mobil Oil advertisement. (A call-out

in the article quoted an oil company ad, "Consumers and legislators should ask if mandated electric vehicles are solving a problem or if, in fact, they are contributing to a problem.") It seems yet again proof of an uphill battle to implement progress.

One more thing. I just received a "Lead Acid Battery" booklet from Lindsey Publications (PO Box 538, Bradley, IL 60915). It's a very informative and practical booklet on L.A. batts. It's as good as Richard Perez's "Battery Book." It should be well dog-eared and on all RE users' library shelf.

And last, I just came across "Renewal!," HP 57 page 100, and from my point of view, every address label has a clear and precise subscription cutoff date noted!!! Anybody who doesn't take note of that concise message is a perpetual procrastinator! And if they miss their next issue of HP then they can buy it off a magazine rack somewhere or order a back issue when they do resubscribe. Guess they didn't learn the "Don't hand in late homework" lesson in grade school. Bye for now. R.A. Cameron

*Hey, R.A., I guess we can count on you to read that mailing label! Thanks for saving trees and energy! I agree with you on Detroit's attitude to electric vehicles. If we get anything useful out of them, it will be because they let Toyota or Honda do it first and capture the market. Richard Perez*

**More "Read Your Label"**

Keep 'em coming. I was a little blown away by the reader who said it was too much trouble to turn his HP 180˚ to read the mailing label. It must be a major imposition to check his battery water once in a while! Better to have you print up 10,000 plus notices a year, not to mention the postage. The one thing that really gripes me about National Geographic is that they start hounding you six months early and never let up. I'll bet I get 4 notices before I finally pay it (when it's due). Don't do it—it's refreshingly different and better for the planet.

Tell Kathleen how much I enjoyed her Home & Heart in HP 57. It was great.

I miss SEER (Willits or Ukiah, CA) and Wisconsin is a bit far for me. I seem to need the support group. I count every watt and every drop yet everything seems to be in short supply. I have to admit to times of envy when my siblings and "in town" friends have their houses lit up like a Christmas tree. I know it's wasteful but they CAN do it. My system grows slowly as I can afford it out of pocket. Well, spring is just around the corner and I suppose I'll snap out of it soom and remind myself to count my blessings.

Keep up the good work. Congrats on your upcoming indoor plumbing—I still remember the pit.

PS. I plan to complete construction on a mega-duty generator house this year. It's a mostly underground $5,000 job. If I'm really lucky I won't need it some day. Steve Borgatti, Yreka, CA

*Thanks for the flowers, Steve. I know what you mean about grid envy—but you're doing it the right way—a PV module at a time! Eventually you'll have the solar you need, and along the line you've learned the difference between what you want and what you need. Perhaps the greatest sin of modern America is that one can live a life here and never even think about the difference between wants and needs. There's more to life than paying the electric bill! Richard Perez*

**Water Distillation Answer**

I've just enjoyed my 1st copy of HP (#56) and I must say thank you. I have never witnessed so much information on alternative energy.

Please may I respond to Thomas Melville's request for info on water distillation. The text "Direct Use of the Sun's Energy" by Farrington Daniels cites a solar distillation plant used in Chile from 1872 to the early 1900s that produced 6000 gallons per day from sea water. The plant used 51,000 sq ft of glazing which works out to 8.5 sq ft per gallon. Surely modern materials could improve this ratio and make solar distillation a possibility.

Also my wife and I have five years experience living in an area of Wyoming with no water source and our needs were met with only 400 gallons per week. We had two children, a garden and did washing, bathing, and all the normal household stuff. So maybe there are some more conservation tips that could help.

Now, can anyone help me with info on small scale steam plants for electricity generation? Thank you all so much, Robin Bunkey, 5904 Moki Road, Casper, WY 82604

*Hello, Robin, and you of all people know that conservation works. Karen and I spent 18 years hauling, by hand, our domestic water in five gallon jerry cans. We used to hump two of these (about a 90 pound load) every day. We ran our household on about ten gallons daily. Now we have a well with a sub pump that cranks out about five gallons a minute into two storage tanks (about 2,700 gallons total) and the water gravity flows into the house. Our house water consumption went from ten to about thirty gallons daily just because we could turn the tap and run it into a sink. As with electricity, conservation is the key to saving water. I've been in low water supply situations and have easily survived on less than one gallon daily. It's all a matter of paying attention to details….*

*I know of no home-sized steam/electric plants at this time. This is an obvious market niche that I hope will be eventually filled. Richard Perez*

**Wood Power!**

Thanks for all the great work! HP just keeps getting better and better! I am still an apartment dweller, but will stay "plugged in" to HP 'til I can go off the grid.

I'm thinking of starting a RE hobby project soon: a woodgas powered car. Woodgas is the carbon-monoxide rich byproduct of partially combusted wood. It is possible to run an ordinary automobile engine on woodgas instead of gasoline. I have an appropriate car, tools, and some know-how.

I extend an invitation to any Seattle area HP readers who may want to become part of the effort or just be a spectator. In particular, I think this might be a great extra-curricular project for any aeronautical or mechanical or chemical engineering students in the area. Please feel free to drop me a line. Kelly Caviezel, PO Box 45636, Seattle, WA 98145 • E-Mail: kelly.m.caviezel@boeing.com

*Hi Kelly. For the last few years there's been a woodgas powered pickup truck exhibiting at the Midwest Renewable Energy Fair. Call them at 715-824-5166 to find out how to contact the exhibitor. Michael Welch*

**More $ for Grid RE**

Can you believe this article? [ed. note: Thomas included a clipping from the Daily Freeman, a NY Catskills newspaper.] Pay more for power produced without fuel or environmental smokestack scrubbers. It seems to me that solar panels and windmills should cost less, not more, to operate. They're paying for a big company's image. Is it just because of ignorance or just being the in-thing to do at the moment. And at the same time, these utilities resist consumer utility intertie for private power production.

Why should they resist being able to sell private power, which doesn't cost them a penny to install or run, at a profit to them?

It's like they're trying to prove that renewable energy costs too much by making us pay for artificially higher prices for it while making their image look good by catching the green wave of the '90s. It's a no lose situation for utilities. Thomas Pidel, Pine Hill, NY

*Hello, Thomas. Well, at this time RE really does cost utilities more than conventional power. Your points are good though, image is important and utilities may be using the greenpower option to make themselves look good without investing too much in renewables. One other thing. Taking into account the subsidies, environmental costs, costs of wars for oil, and the other externalities that are not figured into your utility bill but are paid for by all of us in other ways, RE is cheaper than conventional power. Michael Welch*

**Easy to Read**

From the first issue I saw something about Home Power Magazine caught my attention, but I couldn't put my finger on it. It was easy to read, comfortable, and natural. Then in a recent letter to HP another reader pointed out exactly what it is. Your articles and features start and finish on consecutive pages. No jumping about through the magazine's back pages to find the rest of a story. I just want to add my thumbs up to this format. You folks chose well. The magazine is double a pleasure to read and use. James Wirth, Carlsbad, CA

*Thanks for the flowers, James. Not many folks notice the extra work we put into editing and layout. It's very nice to be appreciated. Richard Perez*

**An Invite**

This is a heartfelt invitation to HP readers. From the tropical South Seas, we express our gratitude to HP for its valuable contribution to the optimal use of creation. We look forward to welcoming here all HP readers who'll venture this way, bringing us their input.

Our islands are intensely sunny, volcanic, blessed by a so beautiful nature, tropical climate, ocean of peace, winds up to cyclone strength, and the weak economy is compensated by World Bank and other financing. Thus all of you who have an idea, a product, an invention, a recommendation, or an experience you feel suitable for our tiny tropical island needs, please write to us.

Where we do have power, it's unreliable, interrupted daily! We're thus longing to use the limitless availability of the sun, etc.

Are computers and especially laptop computers being sold with solar power equipment? Which are the best you know?

HP is great! Do other parts of the world have similar journals? Marco G. Kappenberger, PO Box 1438, Apia, Western Samoa • Phone: +685 24894

*Thanks for the invite, Marco. Hopefully some of our readers will take you up on your offer and help your community out. There are solar modules available for recharging and running your laptop, but I know of no laptop manufacturers that include them as an option. Beware of companies selling PV modules touted specifically to operate laptop computers. These are the very same PV modules which you could buy from most HP advertisers at less than 1/2 the price. Seems if it is marketed as a computer item, then it's much more expensive. Most laptops will run effectively on a single small module (such as the Solarex MSX-10 I run my PowerBook with). All you need is a little technical info and a soldering iron (see my article on laptop PV in HP #38, pages 32–36). For another pub in Home Power's vein, try* ReNew *from Australia (*ReNew*, 247 Flanders Lane, Melbourne, Victoria 3000, Australia • phone: (03) 9650 7883 • E-Mail: ata@ata.org.au • Web: www.subrubia.net/~ata/). Richard Perez*

**California Net Billing Lets Edison Off the Hook**

Just got issue #57, reading it from cover to cover. I would like to purchase Deal #1 on your back issues.

I was a BBS hog for awhile downloading from the HP BBS, but it only goes up into the HP 40s in back issues. I'm sure your sysop was getting tired of me in that I had never downloaded from a BBS, just surfed the Internet, so it was trial and error for me.

I would like to see more attention to cooling rather than heating. I live in the desert and have lots of sunshine and rejoice in a cloudy day. It seems alot of your systems are geared for cooler climates. I'm on the grid now, but am thinking of setting up for a net metering type system.

In the IPP column for HP 57 it was mentioned that Southern California Edison (which is just Edison now) is involved in the AB1890 renewable aspects. At a local EV meeting here in the desert an Edison speaker said that after AB1890 Edison won't have to deal with the high cost of renewables. So I wonder what is going on?

I would like to know where more info on Edison's intentions on net metering can be found. It sure isn't on their Web site.

So, please rush my order to me. I'm sure some of my questions are answered in back issues of your great journal. Raymond Culver, Palm Desert, CA

*Hi Raymond. As sysop (SYStem OPerator) for the Home Power BBS, I can assure you that I wasn't bothered by how much time you spent online. We have three incoming modems, enough for all. A lot of people have troubles getting onto the BBS, especially if they're used to the Internet! The two take different software, and there is no way to get to the BBS from the Internet. There's a pretty good article on using the BBS in HP 39, page 40.*

*Your point is well taken about RE cooling systems. How about it, readers, we could use article submissions in this area.*

*Without context, I can only guess at what the Edison representative at your EV meeting meant by the statement. But, what I fear is now that people can intertie rooftop PV on their own, Edison feels that they are "doing their part" for RE and that it is no longer necessary to investigate or implement utility or other kinds of residential scale renewable energy. This issue's IPP column also touches on Edison's decision. To find out more, contact the guest speaker directly or the company's PR department. They can probably fill you in on the background of the speaker's comment. Michael Welch*

**Cheap, 75% Efficient Modules on the Horizon?**

I ran across an article in the 12/96 issue of Scientific American that I thought would be of interest to other Home Power readers. It seems a company called Advanced Research Development in MA has made plastic PV cells. The material, patented under the name Lumeloid, is a copolymer made with polyvinyl alcohol and polyacetylene. In theory, Lumeloid should be able to convert nearly 75% of incident light into electricity! Present PV technology tops out at around 20%, but commercially available panels are less than 18% efficient.

Even if Lumeloid only gives half of its theoretical efficiency, it would still be almost double the efficiency of the presently available panels. Plus, copolymers are easier to process than silicon which will make end products even cheaper. Imagine! Solar electric panels at 1/2 to 1/4 the present cost per watt!

If there are any readers with contacts in the scientific community, I'm sure many of us would like to be kept informed about

progress with this material. Any takers? Chris White, Charleston, SC

*You've tuned into the current fantasy, Chris. We are all waiting for more efficient, longer lived, and less expensive photovoltaic modules. Right now the magic numbers are round 20% efficiency, at least ten year lifetime, and under $2 per peak watt cost. Think of the problems we could solve! Meanwhile, some of us have been off-grid for over twenty years and we've got tired of waiting. The Lumeloid technology is a definite possibility, but still years from the marketplace. We like to focus on what we can do today, or as I like to say, "Pie on the plate instead of pie in the sky." As soon as a the Lumeloid technology is mass produced and for general sale, we'll be all over it like stink on dog doo. Richard Perez*

**Business Communications**

I've been re-reading back issues of HP in a slightly disorganized fashion, trying to find an article on operating a home business off the grid—particularly telephone options with Fax and Internet hook-ups that actually work while being reasonably affordable. Communication is a major issue with most of us who are living off the grid, but I am not finding and don't remember seeing much in HP regarding this troubling and costly issue.

Would you please advise me as to which issues carried information regarding these questions so that I can find the information I need? I have a Yagi antenna so that my phone reception is generally dependable, and I had a Fax modem that cost about $200 for cellular interface, but it never worked. I need to have access to Fax capability without going 30 miles into Santa Fe to send and receive faxes. Internet access would also be helpful, if access is affordable and reasonably dependable. I hope that these handicaps don't drive me back onto the grid.

I am on a 700 minute a month plan costing me $200 per month plus $0.25 minute over the base limit. Monthly bills are around $300 plus long distance. We get free service on weekends with this plan, but I am wondering about other options available to me, such as a radio phone.

Please help. Also I would like to know if you are aware of any new hardware that may be soon available to solve one or more of these problems. John G. Prentiss, Santa Fe, NM

*Read HP#56, pages 50–54 and HP #56, pages 42–48. Both these articles contain info about radio telephone communications off grid (and off telephone grid). You need to install your own radiotelephone system and the articles in HP#56 will tell you all about it. Ditch the FAX/modem and get a real FAX machine (we like the Hewlett Packard machines and that's not just because they're HP like we are). FAX modems add an additional layer of complexity that you don't need. FAX and modem use different protocols and error tolerances. The modem protocols are much more strict. FAX is fairly loose and works with most cellular and all R/T systems. Modems may be slow on R/T systems and not work at all on cellular systems. If you are paying $300 a month for cellular, then you can pay for an entire R/T system in around a year. Call Electron Connection or Frontier Energy Systems (both listed in this issue's ad index), they both sell and install OptaPhone R/T systems. Richard Perez*

**Improve Power Politics**

What is it with Michael Welch? He appears to have, at the very least, tunnel vision in respect to his apparent vendetta against profit making corporations. At worst, he is on a personal vendetta.

I'm not going to pretend that everything is hunky dory in the corporate world. In fact, over the last few years I've become more of a shareholder advocate than I ever thought I'd be. I've worked in the corporate world, in education, health care, agriculture, and in closely held corporations. I find that most corporations are not under the control of their owners, the shareholders. We individuals get lost in the shuffle and seldom win proxy battles.

Certainly, I can agree with SOME of Mr. Welch's observations. Corporations do take on "a life of their own," sometimes to the detriment of their owners. Corporations do sometimes act with indifference to the issues that others perceive important. Corporations are also found periodically breaking or "bending" the law.

But let's look at reality. Governments have also been major polluters and have other problems. Closed corporations do not necessarily have the ethics ascribed to HP. There are small, closed corporations who cause no fewer problems than the "big guys." Cooperatives and non-profits many times are operated at the whim of their managers, secure in the knowledge that with one vote per member, they are seldom voted out except under extraordinary circumstances.

While he places blame on corporate America for much of the corruption, government representatives at all levels have been discovered in corruption that isn't at all tied to for-profit corporations, like Congressional misuse of benefits voted to themselves, and the power of eminent domain. Individuals can be just as unethical and lack the same consciences as corporations.

Generalization is what really prevents making strides to improve the situation, because it comes from the wrong starting point. Mr. Welch would much better serve all the public he claims to represent if he were able to focus on specific problems of all sectors of society that impact the RE arena, and maybe spend a little less time taking potshots. Instead, develop and promote workable solutions that can be implemented within the economic and social framework that has worked for two centuries, enabling us to even contemplate the technical development of a sizeable RE effort. The easiest way to do this is to develop proposals which work through the existing organizations or develop creative ones, rather than making threatening proposals against some existing target group, like corporations.

The question is, if you threaten someone, even if it's an "artificial person" (aka corporation), is that likely to bring about channels of communication and mutually cooperative activities in the RE area? It doesn't with real people, so why should it in any other organization, profit making or not?

Being an iconoclast is fine, problems need to be identified to be solved. But the effort should lead to progress through fair treatment and evolution, not mudslinging that seems designed to bring about destruction of working systems through what appears to sound greatly like that promoted in leftist revolutions elsewhere and elsewhen. Some of the largest man made ecologic disasters were brought about inside those "non-capitalist" societies. After all, those of us interested in developing greater RE presence sure don't like being targets any more than corporations do. Let's find ways to help all interested organizations work better at incorporating RE into meeting everyone's energy needs well, rather than writing any of them off as the world's biggest villains. Let's instead work toward developing methods to transform the problems with these organizations into good citizenship and stewardship of the world in which we all must live. Ken Hayes, Princeton, MN

*Thanks for the feedback, Ken. Believe me, it is taken to heart. I*

*agree completely that we need to work within the framework of corporate and government organizations toward our common goal of RE. But that ignores the huge potential for positive change that would come out of bringing the corporations back into the fold of community and shareholder conscience. We must work ON the corporation as well as from within.*

*My column changes subjects each issue. The one for* HP 57 *was intended to inform of the powerful and often detrimental role that corporations play in our lives, something that many readers are interested in. Some columns talk about government rolls, some about individual rolls. This issue's PP column discusses the roll of lobbyists and coalitions. But all deal in some way with the politics and political realities of RE. Most offer ways that will make positive change both for RE and other issues. Making corporations into better citizens is one of those ways.*

*There is no doubt in my mind that we will never attain good citizenship and stewardship from many companies without radical, but not really "leftist," reform of the way corporations interact with shareholders, citizens, and our government. Anti-reformists and "fiscal conservatives," often with their own agendas involving getting rich without attention to the side effects, frequently pigeonhole reformists as "leftists" or "liberals." But that is wholly unfair to those that work hard to improve the way things work. It serves to dis-empower the individual by lumping together then pitting one side against the other.*

*Many people invest their money with funds and corporations without considering the "citizenship" of the organization. They are concerned mostly with making a profit. And most shareholder advocates are there to make sure that the company makes lots of money for them, or insist that management go down the road. I truly appreciate the kind of shareholder advocate that is as much into improving the citizenship of the company as it is maximizing the company profits. Hopefully, that's the kind of shareholder advocate HP's readers might be. Michael Welch*

**New EV Column?**

I am a high school teacher who is currently working on an electrathon style vehicle with a small group of students. Would you consider establishing a column dedicated to the growing number small EV racers. Perhaps someone from the Electrathon organization or other experienced scratch built single seater EV builder could share his tech tips and experiences while we can write and share ours. I have purchased copies of Michael Hackleman's latest book. As good as it is, it does not cover building and design considerations in any great depth.

As a Canadian fan of Home Power for over a year, I am pleased to read about some of the Canadian projects you have covered. For us readers who don't have all the back issues, please let us know when your Solar II CD ROM will be on sale. Love your magazine. Keep up the great work! Jim McEachran, Bracebridge, Ontario, Canada

*I consider Electrathon the forefront of EV possibilities. It's affordable, fast, educational, and tons of fun. We'd love to have a regular Electrathon column! Ever since I took a ride in Clark Beasley's "Slingshot" Electrathon racer, I've wanted to sponsor an HP racer, but alas, we're too far from the Electron events and have no time to campaign the racer.*

*Solar2 is in the works. We're having problems getting it just the way we want it and I don't expect it to be for sale until at least mid-summer. The major issue is graphics resolution. We can deliver graphics far better than those printed (when viewed at 4X on Acrobat), but they are slow to load from most CD-ROMs. We are testing it using from 2X to 12 X CD-ROM readers. My attitude is that CD-ROM readers are getting faster all the time and when we use them we are not online (no by the minute charges), so speed is secondary to resolution. What do you think? Richard Perez*

**A College Degree in RE**

In response to J. Yeager's inquiry, I offer my own story. When I was looking for a change of college in 1975, I knew three things: (1) I wanted to help clean up the world, (2) I had good technical abilities, and (3) my future was not to be found in any existing college catalog. I enrolled at Prescott College (Prescott, AZ) which requires a self-defined major, and encourages off-campus study through any appropriate channel, accredited or otherwise. I went off to visit Michael Hackleman, a wind power revivalist. Two years later, by documenting my projects, I ended my "visit" with a degree in Home Energy Management and Wind-Electric Power. I promptly moved to New Mexico, where there is a good market for remote power, and started my business. Come visit and help us celebrate our 20th anniversary.

And by the way, be sure to contact Solar Energy International (HP advertiser) for some of your off-campus study! Windy Dankoff, Dankoff Solar Products, Santa Fe, NM

**Chest Refrigerators**

Thanks for your efforts in putting this fine magazine in my hands It's great!

Could you do a Things that Work! on Dan Alway's fine chest type refrigerators? We have had one for four years and love it, a truly great and efficient unit. Barry Smith, Hinsdale, NY

*Sounds like you are the one to write that Things that Work! article about Dan's refrigerators, Barry. How about it? Richard Perez*

**Other Maine Off-gridders?**

I'm so glad I finally found you guys. We just moved to mid-coast Maine expressly to go off the grid and raise a family. If there are others off the grid in this area who are willing to share, I would love to hear from them. Dennis Grannis-Phoenix, PO Box 31, Warren ME 04864 • 207-273-4656

**New Info=Safety**

I wish I had found your magazine 6 years ago when I bought my first PVs (2 Arco M-75s), a Trace 612, and SCI 3.

I have learned much and continue to learn about the how's and why's of the NEC, current overprotection, lightning, etc. Considering how long I used my first underwired and unfused system without accident or fire, I must have more than my share of dumb luck or divine grace. Richard Knopf, Pepin, WI

*Well, Richard, most of us started with "straight pipes" systems—no overcurrent protection and marginal wire sizes. These days, we know better. Safety first! Richard Perez*

# Ozonal Notes

Richard Perez

As Home Power enters its tenth year of publication, I've decided to revive this Ozonal Notes column. We've used this column to rant and rave about things not strictly concerning renewable energy. I've missed being able to discuss the mechanics of publishing this magazine with its readers. I need your feedback on what we are doing!

**Home Power's People**

The crew which publishes Home Power is quite small—four people full time and two people part time. Here is a short introduction to the folks who make this magazine happen.

I'm the editor in chief, czar of scanning/photographs, database grunt, and publisher. Karen Perez manages the business affairs of Home Power, our subscribers databases, and is our advertising director. Kathleen Jarschke-Schultze is on our front lines—she handles our 800 telephone number and processes all of your subscriptions and other orders (both by phone, mail, and our Web order form). Kathleen also writes the column "Home & Heart." Ben Root is our art director, staff artist, and also writes/edits material for Home Power. Ben is responsible for the great looking color artwork and page layouts you see in Home Power. Michael Welch is a part time associate editor, writes for us, and manages all of Home Power's electronic communications (our BBS, E-Mail, and Web site on the Internet). Myna Wilson is Kathleen's part time assistant and also handles your orders for magazines, CD-ROMs, and books. It's really a very small crew. No one has a secretary.

In truth, we could use at least four more people working full time. This is impossible without making a whole lot more money than we do now. Everyone who works at Home Power is paid the same per hour rate and none of us are getting rich. Home Power, the corporation, has never issued a dividend to our stockholders. To afford a larger crew, we'd have to raise the magazine's price (which we do NOT plan to do) or greatly increase our circulation (which we have been and are now trying to do). I'm not complaining here, mind you. I am deliriously happy to have work which I can believe in. I only wish we could do more….

**Communicating with Us**

It seems like the telephone is always ringing. To preserve our sanity, we only answer the telephone during west coast business hours. If you call outside of business hours, then you will get an answering machine. Our editorial and advertising telephone is 916-475-3179. For orders call 800-707-6585 inside USA and 916-475-0830 outside USA. Our two FAX machine numbers (editorial & advertising at 916-475-0836 and orders at 916-475-0941) are operational all the time.

We receive bushels of postal mail. The first thing we deal with are orders (customer service is job one around here), incoming articles submitted for publication, and then mail asking us questions about renewable energy or what-not. We'd love to be able to answer each and every letter. We simply can't. This small crew has its hands full just publishing the magazine and filling your orders. Postal mail stands a much better chance of being answered if you include a stamped, self addressed, return envelope but we still can't guarantee a reply. Because we all work and live so rurally, we only get to the post office about once a week. This means that the postal mail flow is slow—it will take between three and five weeks before you get an answer to your letter. When an issue nears publication, Ben, Karen and I are busy working on that issue—we don't have time to do anything else. This creates an even slower mail flow through the editorial crew.

All of us have Internet E-Mail and we generally answer this first and more thoroughly. I try to check my email every day and answer it immediately. If you really need an answer to a specific question, then E-Mail is the best way to contact us. It's simply a matter of efficient use of our time—we can respond to about four times more mail via electronic mail than we can via the Post Office. And you will get your answer within a few days rather than a month (or more) via snail mail. If you send us E-Mail regarding your subscription, then please include your snail mail address and telephone number. If you decide to enclose a file with your E-Mail message to us, then be sure that the file is formatted as ASCII TEXT. If you are sending a graphic or something esoteric, E-Mail us first so we can get together on a file format that will work.

No matter how you communicate with us, we ask that you please do as much of your homework as you can before asking questions. About half the questions asked us are either trivial (as in we've already published this

info and one could have looked this up in our index and found what is needed in our back issues), or impossible to respond to (as in, "Please send me all the information you have on solar power."). I enjoy answering readers' questions, but please give enough data to do the job right. Questions like, "How many PV panels do I need to run my house?" are impossible to answer with knowing your energy consumption, climate, and budget. If you give me all the info, then I'll answer your questions. If you don't, then expect a note saying, "Do your homework!", or maybe if I'm really busy, no reply at all.

**Advertising Ghettos?**

It is our design philosophy not to interrupt articles with advertising or to jump around in the magazine with article information. If you look closely, you will see that each article runs from beginning to end, without "continued on page whatever" or inserted advertising. Sometimes (like in this issue with several long articles right up front) we have several pages of advertising in a row. Our advertisers have not complained about this technique and we thank them for this. Several readers have complained about these "ad ghettos," calling us "crassly commercial." What would you like to see? Should we continue running articles uninterrupted, or should we insert ads willy-nilly and make you jump through the magazine to read a complete article? We have a self imposed limit that no more than 33% of an issue is advertising. If we are lucky enough to sell more advertising, then we increase the number of pages of information also. Most other magazines are between 50% and 75% advertising.

**Renewal Notices**

This issue begins our offer to send out subscription renewal notices to subscribers who request them. I have fought this for years, claiming that Home Power readers are a finer lot—capable of reading their mailing labels and resubscribing at the appropriate time. Well, many of you have asked to be sent a renewal notice, and we heard you. If you check the renewal notice box on your subscription form, then we will mail you a postcard saying that your sub has run out (but only one).

**Home Power without the Dead Trees...**

We are experimenting with distributing Home Power electronically. The advantages are obvious—getting the issue weeks in advance of snail mail, no energy wasted in transportation, and no dead trees. We are looking for a number of readers who are willing to act as guinea pigs for electronic distribution. The issue will be an Adobe Acrobat PDF file. If you don't have the Acrobat Reader you can download it for free from our Web site at: www.homepower.com. The file is in full color and is about 5 MegaBytes in size, so you must have enough disk space and time for the download. If you want to help us experiment with electronic distribution, send me E-Mail saying so (richard.perez@homepower.org).

Eventually we hope to offer subscriptions to Home Power electronically for those who wish it. The subscription cost will be lower than snail mail and delivery will be very quick. We are thinking of our international readers especially. International delivery can take months and is problematic. For example, a subscriber in Kenya, Africa recently discovered that his mail person was stealing his copies of Home Power and selling them on the street. We are considering sending the issue as an attached PDF file via E-Mail, or having you check into our Web site and download the issue using a password for security. Any preferences between these two techniques?

**This is Your Magazine**

Ever since we started publishing Home Power in November of 1987, we have tried to give you the information you need to make renewable energy a reality in your life. We can do this better with your help and feedback. Let us know what info you need and we'll try our level best to find it. We also need your article submissions. A large percentage of our articles come directly from readers. Imagine seeing your home featured as a System article. We want you to write about your Homebrews and experiences in areas of RE, and if you've been seriously testing RE equipment we'd like to hear about it.

I want to thank all of our readers for your continuing support. You're really the reason the magazine happens.

**Access**

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E-Mail: richard.perez@homepower.org
Web: www.homepower.com

# Q&A

**Wooden PV Racks**
In Home Power #57 on page 33 you stated, do not use wood for making a PV rack. Why not? I have some PVs on a wood rack. Should I replace with metal? Richard Calvert, Lower Lake, CA

*There a five reasons why I don't like wood as a support material for photovoltaic modules. 1. Wood is less durable than metal—it warps and/or rots unless constantly maintained by painting or oiling. 2. Wood is not as strong as metal—this mean the racks must be more bulky and heavier. 3. Wood expands and contracts less than metal—this mechanically stresses the PVs with every daily thermal cycle. 4. Even though all the PV modules frames are wired together for grounding, using a metal rack and grounding the rack offers additional grounding. 5. Metal PV racks help to conduct heat away from the PV module frames during summer operation, while wood conducts heat far less readily.*

*Having said all this, I must admit to getting many letters from HP readers who are entirely happy with the wooden racks holding their PVs. I have also gotten a letter saying that galvanized steel is not appropriate, while our galvanized steel racks show no problems after 12 years in the weather. As with everything, your site's characteristics determine the best materials to use. Richard Perez*

**Overshot Water Wheel Response & Impulse Questions**
I would like to comment and expand on the Q&A letter from Rod Hyatt that appeared in the last issue. Excuse the theory, but I have also considered the benefits and drawbacks of an overshot wheel for micro-hydro power. With a wheel, the power available is found with the formula:

$$P=dM \times G \times H$$

where
P=power
dM=mass flow of water per unit time
G=force of gravity
H=wheel diameter=vertical head

With an overshot wheel the angular momentum of the large wheel is stepped up by a series of gears and becomes angular momentum in the generator.

With an impulse turbine the vertical head is converted to water pressure by a length of pipe using the formula:

$$Pr=H \times D \times G$$

where
Pr=pressure
H=vertical head
D=density of water
G=force of gravity

The water's pressure is converted to velocity by a nozzle and the velocity is converted to angular momentum by the turbine and spins the generator directly. The amount of power produced is highly dependent on the efficiency of the nozzle and turbine shapes, which can vary greatly depending on the pressure and flow rates available.

Both systems would work equally well if there were no friction. Practically, a long pipe converts a vertical head of water to pressure with great efficiency, economy, and no moving parts. A pipe of large enough diameter to minimize friction due to viscous flow is much cheaper than a large diameter wheel. Also, a longer pipe can easily increase the pressure, if the geography allows, but there are practical limits to the diameter of a wheel. A large wheel will need to be massive itself in order to hold the weight of water needed to turn it, and all that weight causes greater friction in the gears needed to step up the rotation. An impulse turbine uses pressure to produce a usable rotation rate, the main part of the friction being hydraulic flow resistance in the pipe and nozzle, which have no moving parts to break down.

That said, I have still considered using an overshot wheel on my stream for these reasons: the flow is extremely variable from a trickle in the summer during a drought to an average of maybe 40 gpm in winter (twice that for a couple of days following a good rain) to enough flow to float a canoe during a heavy downpour. I don't see how a turbine could handle that variation, but with all the gears on a wheel, I think some sort of automatic transmission should be possible. As the wheel turned faster under higher flow its efficiency should improve.

A reservoir is impossible since it would endanger the only road my neighbors have. Also this stream is full of dead leaves and other trash that would surely clog the intake or nozzle of a turbine daily. A flume and wheel should be pretty much self-cleaning and I could supply a 10 foot wheel with less than 100 feet of flume. This is only 1/3 or so of the total head available along 1100 feet of stream bed.

Do you know how to make a water intake clog-proof without a pond of some kind? Is there a turbine design that can accommodate a wide variation in water flow? I have considered experimenting with a hybrid construction, a pipe without a nozzle feeding a light-

weight wheel (bicycle spoke type construction) with Pelton turbine shaped buckets. Tim Vincent, Oak Ridge, TN

*Thanks for answering Rod Hyatt's question, Tim. Most hydros use several layers of screening, each progressively finer, to filter the intake water. Stuart Higg's hydro (see HP#25, pages 7–14) even has motorized brushes to sweep trash away from the input. Most hydro turbines have upper and lower flow limits. They are designed to fit specific hydro environments which is the reason why there are many differing types and sizes. No one turbine design fits all situations. Keep us posted on your hydro experiments! Richard Perez*

**More Water Wheel Response**

Give water wheels a chance…! Yes water wheels run slow, but slow speed/high torque generators are available as are plans to build them. Water wheels became highly developed by the Victorians. They were often fitted with a gear ring on the outer periphery of the wheel giving a high initial step-up ratio and avoiding huge axle torques which would otherwise have to be transmitted through the wheel.

VITA, 1815 N. Lynn St., Suite 200, Arlington, VA 22209 produced the excellent "Design Manual for Water Wheels," by Wm. G. Ovens, and for a good technical historical development of water wheels see "Stronger than a Thousand Men. The History of the Vertical Water Wheel," by Terry S. Reynolds, 1983, John Hopkins University Press. Michael Munro, South Glamorgan, U.K.

*Thanks for the info access on water wheels, Michael. We have only profiled one overshot water wheel system, see HP# 37, pages 6–11. This system geared up the 12 foot diameter water wheel 160 times before hitting the 117 vac generator. In sites with high flow and low head, water wheels will work where turbines won't. Richard Perez*

**QRM, Good Buddy**

I have a slight problem with my new Power to Go 1500 watt inverter. I live in the desert with many CB radio nuts and my inverter causes high noise on CBs in the area. I may get kicked off the desert over it! I mounted it in a steel box grounded to the RV and got some improvement. What can I do? Lester Rose, Deming, NM

*Well, Lester, Radio Frequency Interference (RFI) has always been a problem with inverters. The 12 VDC cables feeding the inverter are acting as antennas which broadcast the RFI produced by the inverter. In addition to grounding the inverter's case there are two other things you can do to reduce RFI. 1. Make a tightly twisted pair out of the two cables feeding 12 VDC to the inverter. I know that twisting 0 gauge cable is difficult, but this technique really works. 2. Add RF bypass capacitors to the main battery terminals and at the back of the inverter. Place 0.1 µF disk ceramic capacitors (use 25 V rated in 12 VDC systems and 50 V rated in 24 VDC systems) from positive to negative at the back of the inverter and where the inverter cables attach to the battery. These capacitors are cheap and available from Radio Shack. They acts as short circuits to the RFI. Richard Perez*

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